

# JOURNAL

OF THE

## AMERICAN WATER WORKS ASSOCIATION

**VOL. 22**

**JULY, 1930**

**No. 7**

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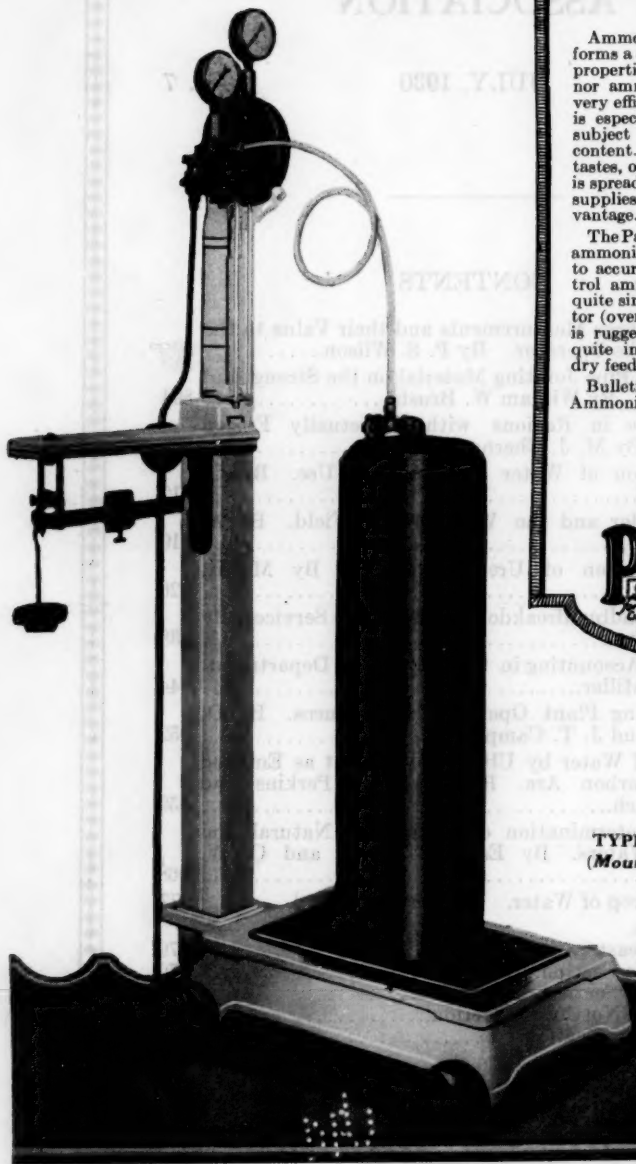
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# AMERICAN WATER WORKS ASSOCIATION

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## HYDRANT DISCHARGE MEASUREMENTS AND THEIR VALUE TO THE WATER WORKS OPERATOR<sup>1</sup>

By P. S. WILSON<sup>2</sup>

An admirable paper having almost the same title as the present one was presented before this association by George W. Booth and published in *THE JOURNAL*, Vol. 12, No. 2, October, 1924. The present paper covers the same field to a limited extent. It is the present writer's purpose, however, to emphasize the value of the subject particularly to the water works operator, as well as to present some additional methods of conducting the work.

Actual measurements of the flows taking place in a water distribution system may furnish extremely valuable information to the water works operator. A water distribution system is different from most of the equipment with which other business is conducted. It is buried underground and is not subject to ready inspection. The greater portion of it has not been seen for a generation or more. Its present operator has never seen most of it and almost all he knows of it is what he has been told second or third hand or what he learns from maps and records which are in many cases woefully deficient. What information he does obtain about his system is mostly history,—what it was when it was last seen, years before, not what it is now. It is on account of these conditions that actual tests and measurements

<sup>1</sup> Presented before the New York Section meeting, April 24, 1930.

<sup>2</sup> Superintendent of Operation, Community Water Service Company, New York, N. Y.

are of such great value. One can theorize for a long time as to whether a certain valve is open or shut and one may even operate the valve one way or another and still not know much more than before. But if the water in proper quantity flows through that valve and evidences itself on the other side, then the question is settled and there is no more possibility for argument.

#### METHODS OF MEASURING FLOW

There are two principal methods of making field measurements of the flows in water distribution systems. One of these is by means of the Pitot orifice tube inserted through a corporation cock in the side of a main. Such measurements when properly applied are of inestimable value. A method of making tests more readily available to the operator is, however, by the measurement of hydrant discharges, since less time, expense, and equipment are necessary. Measurements so made are not, of course, a complete substitute for Pitot measurements in the pipes, but in many cases they may suffice in themselves to answer the questions at hand. Even if they do not, they always form a valuable guide and adjunct in the making of further and more elaborate tests, if these are later found necessary.

Measurement of the discharge from an ordinary fire hydrant with sufficient accuracy for most practical purposes is not difficult and every water works manager or superintendent should be able and equipped to make such measurements. By the exercise of care and good judgement, results may be obtained within fairly close limits of accuracy. Rough and ready methods are for the most part amply sufficient, since, for the purposes usually involved, the conclusions arrived at would not be changed by a variation of five or ten percent one way or the other in the test results. Some of the rather approximate methods here given must be judged with this fact in mind. A rough method resulting in some approximate data is of more value than a more exact method requiring facilities not available and, therefore, resulting in no data at all.

The discharge from a hydrant nozzle is determined from the size or cross sectional area of the emerging stream and from the average velocity of that stream. From these two figures the discharge, in gallons per minute or other terms, may readily be computed or may be directly read from tables or diagrams previously prepared.

The diameter or size of a stream of water emerging under pressure from an orifice is practically the same as the size of the orifice if the

inner or entrance edges of the orifice are sufficiently rounded, or if the length of the nozzle is great enough. Observation of the flow from hydrant nozzles shows that the flow completely fills the nozzle as a general rule. Therefore, a simple measurement of the internal diameter of the hydrant nozzle serves to make known the diameter of the stream of water. The entrance to the nozzle from within the barrel may occasionally, particularly in some old styles of hydrants, and hydrants with independently gated nozzles, be sharp enough to cause the emerging stream to be contracted slightly below the size of the nozzle and if such an effect is noted it should be allowed for in the diameter used. In case the stream of water does not completely fill the nozzle at the bottom or top, then allowance must be made for that fact. Such conditions, however, may usually be avoided. If the flow is insufficient to fill a single hose nozzle then it is usually too low to admit of a velocity determination.

The internal diameter of each nozzle used should be carefully measured to the nearest one sixteenth of an inch. An ordinary carpenter's rule is satisfactory for this purpose.

The average velocity of the emerging stream of water may be determined in either of two ways. The most common method is by the use of a hydrant Pitot tube which may be inserted into the stream and which transforms the velocity head of the stream into the equivalent pressure head and registers it on an attached pressure gage. This instrument is shown in figure 1. It consists of a hollow blade or cut-water shaped so that it may be thrust into the stream without unduly deflecting it. At the end of the blade is a small opening which points directly against the flowing water. The force of the stream striking into this opening creates a pressure in it which is transmitted through the hollow blade and handle to the pressure gage. The gage is an ordinary good pressure gage, except that it should be graduated to read more closely than most gages. The gage most frequently used is graduated every pound and only reads up to about fifty pounds per square inch pressure. It must be a good grade of gage to maintain its accuracy with such close reading. For some purposes it is of value to have a very low pressure gage graduated to half pounds. Sometimes the Pitot tube and the gage are held in place in the stream by a device which clamps over the outside of the nozzle. This device is not ordinarily considered necessary, however, and its use results in greater damage to the Pitot tube if struck by a stone or other object carried by the water. The edges

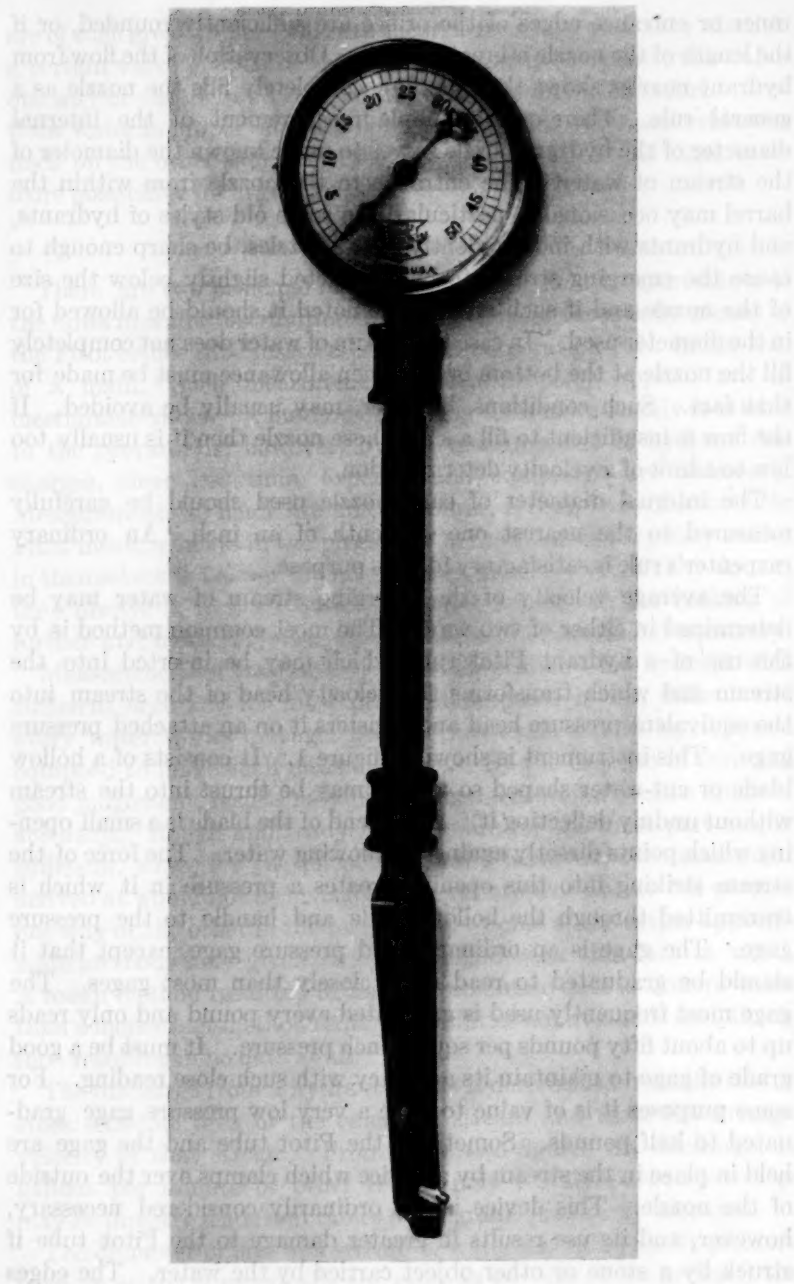


FIG. 1. HYDRANT PITOT TUBE WITH GAGE

of the blade and the small orifice into it must be kept sharp and symmetrically shaped or the accuracy of the instrument will be seriously affected.

In use the Pitot tube is held in the stream and the pressure read with the small orifice at the center of the stream and pointing directly against the flow. Occasionally on large nozzles it is advisable to take a rough average of the pressures across the stream at different points horizontally and vertically. This is not often necessary since in most cases the pressure at the center will be found to be practically the average. In any case the pressure very near the edge, within about one fourth inch, should not be considered. Near the edge the water is slowed up by rubbing against the nozzle and the effect of this is allowed for by the coefficient of the formula, discussed later.

The other method of determining the velocity of the stream, and one which has been occasionally found more convenient by the writer, consists merely in placing on one of the hydrant nozzles a cap having an ordinary pressure gage tapped into it and allowing the discharge to take place through the other nozzles. Due to the free discharge from the nozzles, practically all of the pressure head remaining in the barrel during the flow is transformed into velocity head in the jets. Since that is practically the only source of velocity head in the jets, the ordinary pressure gage indicating the pressure in the barrel will read substantially the same as a gage on a Pitot tube held in a jet. This fact may be readily confirmed by trial. In this way the discharge of a hydrant may be measured with fair accuracy without a Pitot tube merely by the use of a pressure gage, the gage reading being used to compute the discharge in the same manner as if it were a Pitot tube reading. The same type of gage should be used for this method as described above for the Pitot tube. Any pressure gage may be used, however, the accuracy of the results depending upon the accuracy of the gage and the closeness of the graduations and readings.

Figure 2 is a photograph showing a Pitot tube with gage being held in the stream from one hydrant nozzle while a pressure gage on the other nozzle is at the same time indicating the pressure in the barrel. This illustrates the two methods of determining the velocity head of the stream. Unfortunately the photograph does not make it possible to see what the gages are reading; actually they show the same, 18 pounds per square inch, and indicate a discharge of approxi-

mately 700 gallons per minute. In using the Pitot at low velocities, where a quarter pound makes an appreciable difference, the instrument should be held horizontally so that the pressure gage will be at the same elevation as the nozzle.



FIG. 2. SHOWING TWO METHODS OF DETERMINING THE VELOCITY OF NOZZLE DISCHARGE

Pitot tube in stream from one nozzle, while pressure gage on the other nozzle indicates the pressure in the barrel with substantially the same reading.

With the same accuracy of gage readings the only inaccuracies in the second method as compared with the use of the Pitot tube are in the fact that there is a slight loss of head in entering and flowing through the nozzle and the assumption that the velocity head in the barrel at the point of pressure reading is zero. This latter assumption is justified because the velocity in the barrel is low compared to

that in the jet and the pressure reading is taken opposite or above the other nozzles which are discharging. In any case, as before mentioned, trial will show that the results are in general substantially the same in both methods. If the hydrant Pitot tube is at hand, its use is best and most convenient; the availability of the other method, however, should always be borne in mind.

The pressure gage on one nozzle, of course, prevents the use of that, nozzle for the discharge of water. This is not always a disadvantage, however, particularly when the hydrant is equipped with a steamer nozzle.

A fact which may readily be perceived from the foregoing is that, when measuring the velocity with a Pitot tube, a reading need be taken, except as a check, in only one of several nozzles of a single hydrant discharging at once, since simultaneous readings in all of the nozzle streams should read practically alike, the difference in elevation being negligible.

#### FORMULA FOR FLOW

In order to allow for the fact that the velocity of the jet as determined by either of the methods above does not take account of the very low velocity around the edges where it comes in contact with the nozzle, as well as to allow for a possible slight contraction of the jet, it is necessary to make use of a coefficient in computing the results. This coefficient has been determined experimentally by checking the hydrant measurements against other and more accurate means of metering the flow. The coefficient should, theoretically, be different for different hydrants, but it is sufficiently accurate for the purposes and means of measurement under discussion to use an average figure which has been found by experiment to be about correct for most cases. The figure usually used is 0.90 and thus the actual discharge when obtained is nine tenths of the figure computed from the diameter and pressure head measurements.

The formula usually used in determining hydrant discharge is as follows:

$$\text{Discharge in gallons per minute} = 27 \times d^2 \times \sqrt{p}$$

Wherein  $d$  = the internal diameter of the hydrant nozzle in inches  
 $p$  = the velocity head of the stream expressed in pounds per square inch as indicated either by the Pitot gage or the gage on a closed nozzle.

TABLE 1

*Hydrant discharge*Gallons per minute =  $27 d^2 \sqrt{p}$ Hose nozzle—nominal diameter  $2\frac{1}{2}$  inches =  $d$ 

| $p$            | $2\frac{1}{8}$ | $2\frac{1}{2}$ | $2\frac{7}{8}$ | $3\frac{1}{8}$ | $3\frac{1}{2}$ | $3\frac{3}{4}$ |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| $\frac{1}{4}$  | 70             | 80             | 80             | 80             | 90             | 90             |
| $\frac{1}{2}$  | 100            | 110            | 110            | 120            | 120            | 130            |
| $\frac{3}{4}$  | 120            | 130            | 140            | 150            | 150            | 160            |
| 1              | 140            | 150            | 160            | 170            | 180            | 190            |
| $1\frac{1}{4}$ | 160            | 170            | 180            | 190            | 200            | 210            |
| $1\frac{1}{2}$ | 180            | 190            | 200            | 210            | 220            | 230            |
| $1\frac{3}{4}$ | 190            | 200            | 210            | 220            | 230            | 250            |
| 2              | 200            | 210            | 230            | 240            | 250            | 260            |
| $2\frac{1}{2}$ | 230            | 240            | 250            | 270            | 280            | 290            |
| 3              | 250            | 260            | 280            | 290            | 310            | 320            |
| $3\frac{1}{2}$ | 270            | 280            | 300            | 320            | 330            | 350            |
| 4              | 290            | 300            | 320            | 340            | 350            | 370            |
| $4\frac{1}{2}$ | 310            | 320            | 340            | 360            | 380            | 390            |
| 5              | 320            | 340            | 360            | 380            | 400            | 420            |
| $5\frac{1}{2}$ | 340            | 360            | 380            | 400            | 420            | 440            |
| 6              | 350            | 370            | 390            | 410            | 430            | 460            |
| $6\frac{1}{2}$ | 370            | 390            | 410            | 430            | 450            | 470            |
| 7              | 380            | 400            | 420            | 450            | 470            | 490            |
| $7\frac{1}{2}$ | 400            | 420            | 440            | 460            | 490            | 510            |
| 8              | 410            | 430            | 450            | 480            | 500            | 530            |
| $8\frac{1}{2}$ | 420            | 440            | 470            | 490            | 520            | 540            |
| 9              | 430            | 460            | 480            | 510            | 530            | 560            |
| $9\frac{1}{2}$ | 440            | 470            | 490            | 520            | 550            | 570            |
| 10             | 460            | 480            | 510            | 530            | 560            | 590            |
| 11             | 480            | 510            | 530            | 560            | 590            | 620            |
| 12             | 500            | 530            | 560            | 590            | 610            | 650            |
| 13             | 520            | 550            | 580            | 610            | 640            | 670            |
| 14             | 540            | 570            | 600            | 630            | 660            | 700            |
| 15             | 560            | 590            | 620            | 650            | 690            | 720            |
| 16             | 580            | 610            | 640            | 670            | 710            | 740            |
| 17             | 600            | 630            | 660            | 700            | 730            | 770            |
| 18             | 610            | 650            | 680            | 720            | 750            | 790            |
| 19             | 630            | 660            | 700            | 740            | 770            | 810            |
| 20             | 640            | 680            | 720            | 750            | 790            | 830            |
| 22             | 680            | 710            | 750            | 790            | 830            | 870            |
| 24             | 710            | 750            | 790            | 830            | 870            | 910            |
| 26             | 740            | 780            | 820            | 860            | 900            | 950            |
| 28             | 760            | 810            | 850            | 890            | 940            | 980            |
| 30             | 790            | 830            | 880            | 920            | 970            | 1020           |

This formula may be briefly derived as follows:

$$\text{Discharge} = (\text{area of stream}) \times (\text{average velocity})$$

Using the formula for the area of a circle, changing  $d$  to feet, and using the fundamental hydraulic formula stating that the velocity equals the square root of  $2g$  multiplied by the square root of the pressure head, also changing  $p$  from pounds per square inch to feet head, this becomes:

$$\begin{aligned} \text{Discharge in cubic feet per second} &= \frac{3.14 \times d^2}{4 \times 144} \times \sqrt{2g} \times \sqrt{2.31 p} \\ &= 0.00545 \times d^2 \times 12.2 \times \sqrt{p} \\ &= 0.0665 \times d^2 \times \sqrt{p} \end{aligned}$$

$$\text{Discharge in gallons per minute} = 29.9 \times d^2 \times \sqrt{p}$$

( $g$  is the value of the acceleration due to gravity and equals 32.2 in foot and second units.) The coefficient, 0.9, is then introduced making the formula

$$\text{Gallons per minute} = 26.9 \times d^2 \times \sqrt{p}$$

For convenience the 26.9 may be rounded off to an even 27 without introducing any error of importance.

From this formula tables may be constructed in which the discharge is given for each combination of diameter of nozzle and Pitot pressure head and from which the result of the measurement may therefore be read directly without computation. A specimen of such a table is shown in table 1. The discharges in this table are given to the nearest ten gallons per minute. Tables may be made up very conveniently to fit in field note books. For special purposes they may be abbreviated or enlarged either in range or in closeness of reading.

Another method of handling the formula is by the use of diagrams and in figure 3 a particularly convenient form is shown for such a diagram which the author has never seen in use elsewhere. In this diagram measurements horizontally from the origin or zero are proportional to the square root of the Pitot pressure head,  $\sqrt{p}$ , and measurements vertically are proportional to the discharge of the hydrant nozzle in gallons per minute. An inclined straight line passing through the origin then represents each value of the nozzle

diameter,  $d$ . A heavy line is drawn for each size of nozzle in use using the theoretically correct value of  $d$ ,—for example  $2\frac{1}{2}$  inches for an ordinary hose nozzle. Light lines are then drawn on the diagram below and above the first ones representing  $\frac{1}{8}$ -inch undersize and oversize of each nozzle. From these three lines values for each  $\frac{1}{16}$ - to  $\frac{1}{4}$ -inch under and over the nominal sizes may readily be read on the diagram.

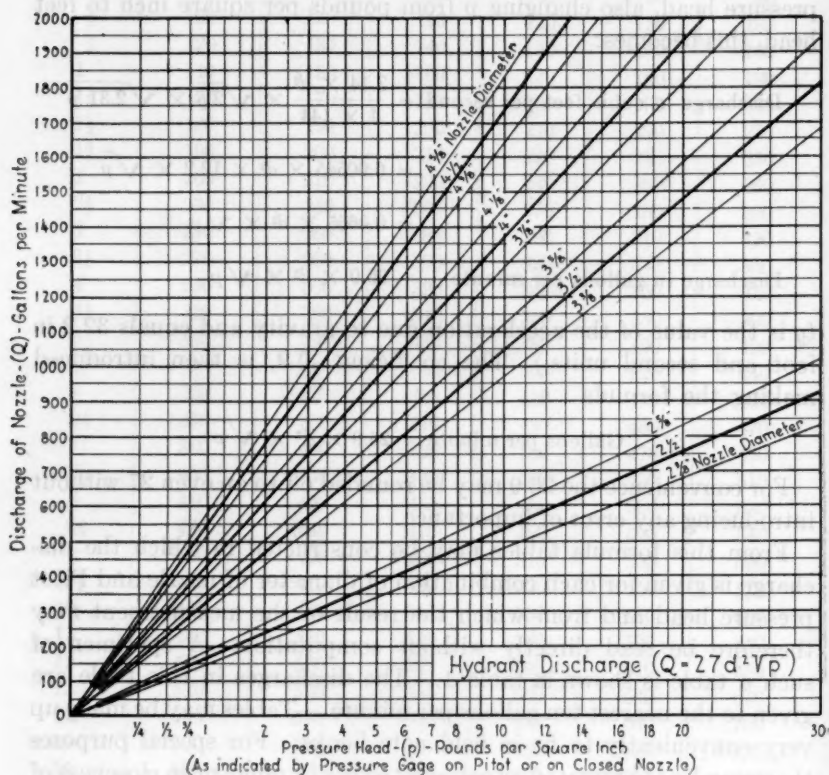


FIG. 3. HYDRANT DISCHARGE DIAGRAM

This covers the usual variation of the nozzles. It is to be noted that the horizontal distances on the diagram are not directly proportional to the pressures but to the square roots of the pressures. This results in uneven spacing of the figures, but by so constructing the diagram the lines representing the nozzle diameters may be drawn straight, whereas otherwise they would be curved. The uneven spacing of the pressure lines makes accurate interpolation difficult,

but enough lines are drawn on the diagram to make this unnecessary. Having made a discharge measurement this diagram is used as follows: Pick the vertical line representing the Pitot pressure reading, follow it up or down to where it crosses the line representing the actual measured internal diameter of the nozzle, estimating where that line would be if the correct one is not on the diagram. Then follow the horizontal lines to right or left and read the discharge on the vertical scale.

A careful study of the formula and the tables and diagrams leads to a number of important observations on the carrying on of this work. When the Pitot pressure reading is low, a slight difference in the reading will result in a very large percentage difference in the result, whereas at the higher pressures a half pound or even a pound does not make much difference. For instance the difference between 1 and 2 pounds per square inch makes about 40 per cent difference in the discharge while the difference between 10 and 11 pounds per square inch makes only about 5 per cent difference. This fact is the reason for making the pressure differences in the table and diagram smaller in the lower range. It also indicates the necessity for making very careful Pitot pressure determinations in the field, particularly at low pressures. Gages should be closely graduated as before mentioned and should have at least three inch dials. On particular work they should be calibrated with a dead weight tester before and after using and a correction table applied to the readings if necessary. Gages should be handled gently and with care so as to maintain their accuracy. Since they will probably not read as high as the static pressure in the mains, care should be taken when taking pressures on a closed nozzle not to subject them to too much pressure. Other gages must, of course, be provided for taking the direct main pressures.

It will also be noted that a  $\frac{1}{16}$ -inch difference in the diameter of the nozzle makes a much greater percentage difference at high discharges than at low ones. This is the opposite from the effect of the pressures. In spite of this it will usually result in most accuracy to use as few and as small nozzles as possible in a measurement. The use of steamer nozzles is advised only on work where approximate results would be satisfactory. Further experiments may show that a slightly different coefficient should be used in computing the discharge of the larger sizes of nozzles.

## PRACTICAL USES OF HYDRANT FLOW TESTS

There are many varieties of tests, measurements and experiments which may be performed on a distribution system through the use of hydrant discharge measurements. The most obvious one is, of course, to determine what amount of water is available at a given hydrant or at a given point in the system for use by the fire department. This test is the one usually made by the engineers of the National Board of Fire Underwriters in rating a system for fire protection. So much has been written on such tests that they need be only mentioned here. Simultaneous readings are taken on as many hydrants in a group as are needed in order to develop the capacity of the system. At the same time a record is kept at an adjacent hydrant, not discharging, of the residual pressure. From a set of such readings the discharge capacity of the system at that point with any residual pressure may be known. For further details of these tests the reader is referred to the paper by Mr. Booth mentioned above, and to much other literature on the subject. Such tests may indicate not only whether the system has the desired capacity or not, but they may be amplified to give information as to what work should be done to increase the capacity. For example, by taking a record of the pressures in the system during the flow test at various points progressing back toward the source of supply, it may be conclusively shown whether the restriction is in the principal supply mains or whether it is in the local mains adjacent to the test. By cutting out certain mains during the test still further information may be gained as to the actual conditions existing; closed valves or other obstructions, defective hydrants, or large leaks may be discovered and located. This work opens up a great field for the display of ingenuity on the part of the operator since the exact procedure is subject to unlimited variation and depends upon the arrangement of the particular system under test.

Hydrant discharge measurements may be used in making determinations of the friction coefficient in certain mains of the system. By isolating a stretch of pipe so that the feed into it is from one end only, a flow through it may be created which can be measured at its discharge from a hydrant or hydrants at the end of the section under test. If pressures are taken simultaneously during the flow at intermediate hydrants or other connections of known elevation along the main, then from the data so obtained the loss of head and the

friction coefficients of each section may be computed. Obstructions or closed valves may also be located through the unequal drops in pressure in different sections along the line when such difficulties exist.

Such tests are of value in determining the necessity for or advisability of cleaning a main and in determining the effectiveness of the cleaning after it has been performed. If they are made periodically after cleaning, valuable data will be obtained as to the speed and degree of the return of roughness in the pipe, thereby indicating the true value of the cleaning and the advisability of recleaning or of cleaning other mains.

In those cases where a company's records are inaccurate, loss of head tests may be quickly made to provide an accurate indication of the size of any main which is in doubt.

When flushing out sediment or other deposits from the pipes of a system it is of great value to make a rough check of the discharge of the hydrants or blow-offs in use in order to be certain that a sufficient velocity has been created in the main or mains supplying that point to properly clean them out. From 4 to 6 feet per second velocity is usually considered the minimum necessary to flush out a main so that the material remaining will cause no further difficulty from being stirred up by normal flows.

It is difficult to foresee all of the benefits which may come of making tests such as these of a distribution system. One of the greatest benefits is that, no matter what their nature, they will usually result in an unusually thoughtful and detailed consideration of the system on the part of the men who are operating it. The effort to interpret and account for results and the resulting further tests will frequently uncover unsuspected conditions quite different from those which originally suggested the tests. Errors in the maps and records, as well as definite faults in the system, may be discovered.

friction coefficients of each section may be compared. Obstructions at closed valves may also be located through the unusual drops in pressure in different sections along the line when such difficulties exist.

## EFFECT OF RIGID PIPE JOINTING MATERIAL ON THE STRENGTH OF PIPE BELLS<sup>1</sup>

BY WILLIAM W. BRUSH<sup>2</sup>

The experience of the writer with the use of cast iron pipe indicated to him that, in general, cast iron pipe 8 inches and smaller in diameter was weaker in the body of the pipe than in the bell when acting as a beam. For 12-inch and larger pipe the experience indicated that the point of minimum strength was located at the bell rather than in the body of the pipe. This opinion was based upon the reports of breaks in water mains, and observation of such breaks covering many years' experience. The writer was, therefore, surprised to find that even for the smaller pipe the bell is the weakest point in the pipe when acting as a beam, and that the reason for the majority of breaks occurring in the body of the pipe when acting as a beam, is due mainly to the flexibility of the jointing material.

This condition was clearly shown in connection with a test made at the Florence Foundry on January 9, 1929, which was carried out for the purpose of indicating the difference between sand spun and sand cast (pit cast) pipe, when acting as a beam. To test the strength of the bell with a clear span between the points of support of 11 feet 6 inches, or approximately the length of a cast iron pipe, the writer was informed that it was necessary to make a stiff joint, using zinc, as otherwise the pipe would not break, except after excessive deflection. With this zinc joint it was possible to break the pipe at the bell without material deflection, and both sand spun and sand cast pipe were also broken with a similar span supported at each end, so that the break would occur in the middle of the pipe. The pipes were 8 inches in diameter and represented A. W. W. A. Class B pipe having an assumed wall thickness of 0.51 inch. The actual thickness of the sand spun pipe was found to be 0.505 inch, and of the sand cast pipe 0.557, the latter corresponding to Class C pipe. The full size dimen-

<sup>1</sup> Presented before the Toronto Convention, June 28, 1929.

<sup>2</sup> Chief Engineer, Department of Water Supply, Gas and Electricity, New York, N. Y.

sions of the bell are shown in figure 1, and the results obtained in the tests are shown in figure 2. It will be noted that the results of the tests were as follows:

| TYPE OF PIPE   | BREAKING LOAD<br>WHEN APPLIED<br>AT BELL | BREAKING LOAD<br>WHEN APPLIED IN<br>CENTER OF PIPE |
|----------------|--|--|
|                | pounds                                   | pounds   |
| Sand cast..... | 10,000                                   | 25,500   |
| Sand spun..... | 15,000                                   | 31,200   |

It will be seen from the above that with a rigid jointing material the 8-inch pipe of the sand cast type broke at a load of only about 40

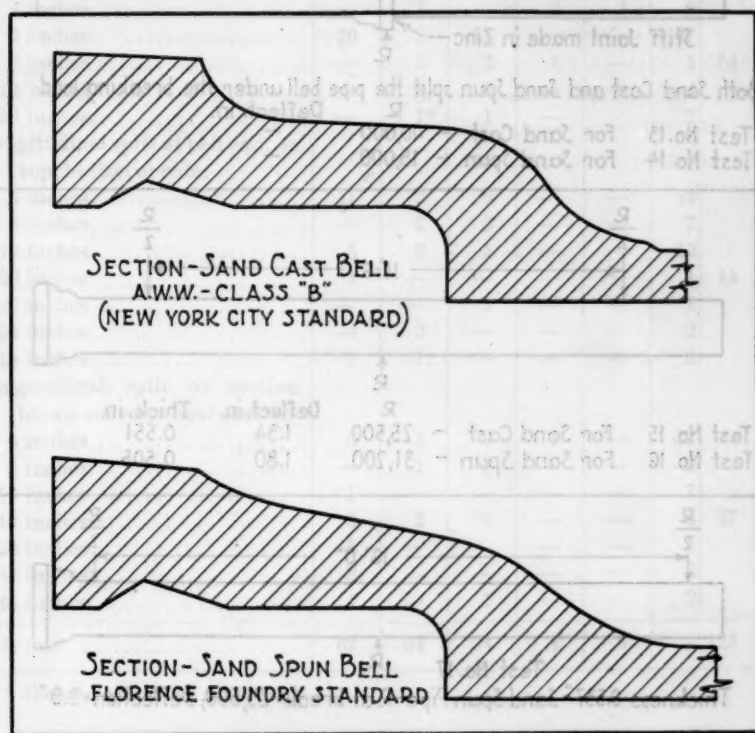


FIG. 1. BELLS FOR 8-INCH CAST IRON PIPE. SAND CAST AND SAND SPUN PATTERNS. COMPARISON OF CROSS-SECTIONS OF BELLS OF CAST IRON PIPE BROKEN UNDER TEST AT FLORENCE FOUNDRY, FLORENCE, N. J., JANUARY 9, 1929

per cent of that applied to the barrel of the pipe, and that for the sand spun pipe the corresponding figure was 50 per cent.

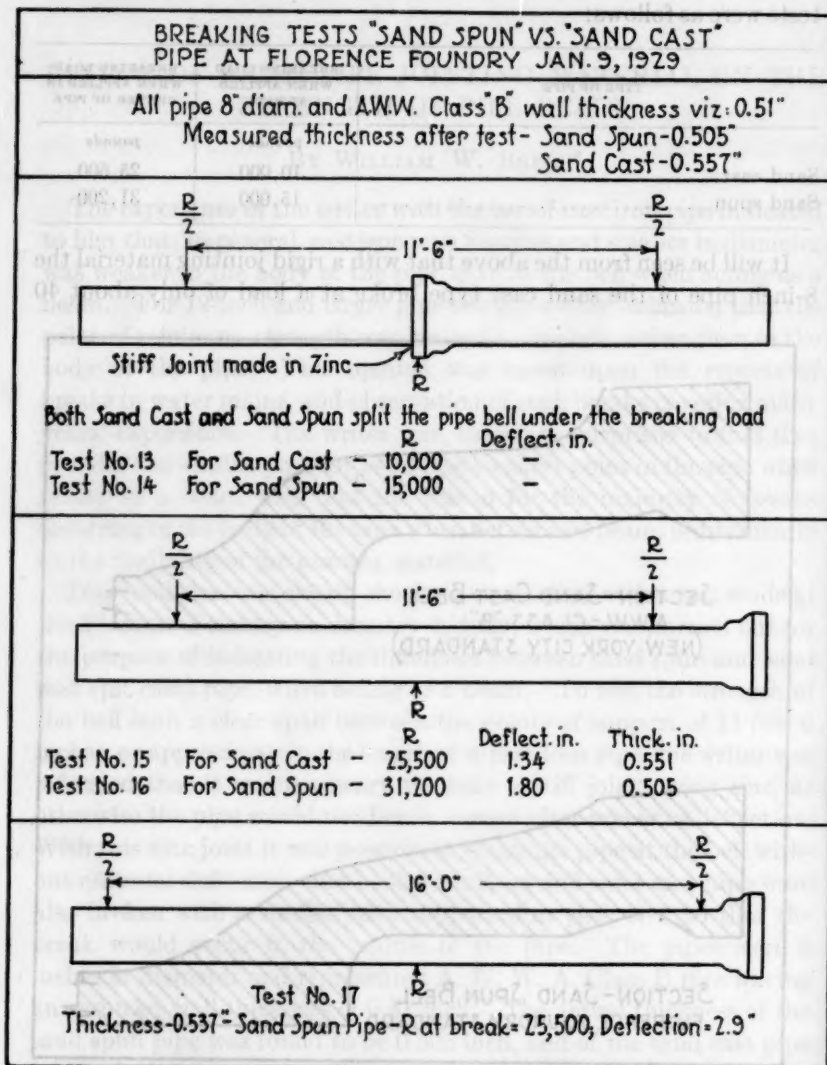


FIG. 2

The results of these tests were most interesting and raised the question as to the extent to which the stiffness of jointing material

would affect the breaking strength of pipe acting as a beam, and also the question as to the proper design of bell of cast iron pipe to make the pipe when laid a structure of approximately equal strength in the bell and body of the pipe when acting as a beam. The New York city

TABLE 1

*Breaks in cast iron water mains, year 1926*

|  | MAN-<br>HATTAN | BRONX | BROOK-<br>LYN | QUEEN | RICH-<br>MOND | TOTAL |
|--|----------------|-------|---------------|-------|---------------|-------|
| Total number of breaks reported.                           | 72             | 46    | 36            | 4     | 4             | 162   |
| Total number of breaks described clearly.....              | 62             | 34    | 34            | 4     | 1             | 135   |
| Transverse breaks:   |                |       |               |       |               |       |
| 4 inches.....  | —              | 3     | —             | 2     | 1             | 6     |
| 6 inches.....  | 29             | 7     | 11            | —     | —             | 47    |
| 8 inches.....  | —              | 2     | 2             | 1     | —             | 5     |
| 12 inches.....   | —              | 2     | 2             | —     | —             | 4     |
| 20 inches.....   | —              | 1*    | 1             | —     | —             | 2     |
| Longitudinal split at bell end, on top, bottom or side:    |                |       |               |       |               |       |
| 6 inches.....  | 11             | 2     | 6             | —     | —             | 19    |
| 8 inches.....  | —              | 2     | 5             | —     | —             | 7     |
| 12 inches.....   | 5              | 6     | 1             | —     | —             | 12    |
| 20 inches.....   | 1              | —     | —             | —     | —             | 1     |
| 30 inches.....   | —              | —     | 1             | —     | —             | 1     |
| 36 inches.....   | —              | 2     | —             | —     | —             | 2     |
| 48 inches.....   | 1              | 1     | —             | —     | —             | 2     |
| Longitudinal split or section blown out at or near centre: |                |       |               |       |               |       |
| 6 inches.....  | 6              | 3     | 2             | 1     | —             | 12    |
| 8 inches.....  | —              | 1     | 1             | —     | —             | 2     |
| 10 inches.....   | 1              | —     | —             | —     | —             | 1     |
| 12 inches.....   | 3              | 2     | 1             | —     | —             | 6     |
| 20 inches.....   | 1              | —     | —             | —     | —             | 1     |
| 36 inches.....   | 3              | —     | —             | —     | —             | 3     |
| 48 inches.....   | 1              | —     | 1             | —     | —             | 2     |
| Totals.....  | 62             | 34    | 34            | 4     | 1             | 135   |

\* Sheared at bridge abutment.

practice is to use lead as a jointing material, and with such a material we find the record of breaks for the year 1926 to be as set forth in table 1. This shows, out of 135 breaks in cast iron pipe from 4 up to 48 inches in diameter, that for the 6-inch size, in which the majority of breaks occurred, in the borough of Manhattan, where the most

extensive disturbance of foundation takes place, there were 29 breaks across the pipe in the barrel, as compared with eleven breaks at the bell end, indicating that, generally speaking, for the 6-inch pipe with lead joints the pipe line as a whole is less likely to break at the bells than in the body of the pipe. For the 8-inch size there are not sufficient breaks upon which to draw a conclusion. For the 12-inch and larger sizes it appears quite evident that the bell represents the point at which the pipe line will generally yield due to settlement.

It is not the intention of the writer to present these facts with a view of advocating any particular form of jointing material. There are reasons why certain forms of jointing material are more advantageously employed in one location than in another. Materials that fit New York city conditions may not fit the conditions in other locations. The writer presents these data as adding information on a subject that he believes has received comparatively slight attention in the past, and that in his judgment deserves serious consideration in the future in connection with the design of cast iron pipe, with special reference to the dimensions of the bell.

| Location        | 6 inches | 8 inches | 12 inches | 18 inches | 24 inches | Total |
|-----------------|----------|----------|-----------|-----------|-----------|-------|
| At bell         | 11       | 1        | 1         | 1         | 1         | 5     |
| Between bells   | 18       | 2        | 1         | 1         | 1         | 23    |
| At manholes     | 1        | 1        | 1         | 1         | 1         | 5     |
| At valves       | 1        | 1        | 1         | 1         | 1         | 5     |
| At other points | 1        | 1        | 1         | 1         | 1         | 5     |
| Total           | 32       | 6        | 5         | 5         | 5         | 53    |

\* Shown at bridge abutment. This shows that for the 6-inch size, in which the majority of breaks occurred in the borough of Manhattan, where the most extensive is to use lead as a jointing material, and with such a material we find the record of breaks for the year 1926 to be as set forth in Table 1. This shows out of 135 breaks in cast iron pipe from 4 up to 48 inches in diameter, that for the 6-inch size, in which the majority of breaks occurred in the borough of Manhattan, where the most

## WATER SERVICES IN REGIONS WITH PERPETUALLY FROZEN GROUND

By M. J. CHERNYSHOFF<sup>1</sup>

Grounds perpetually frozen to a considerable depth produce tremendous difficulties with regard to obtaining water from sources, as well as in its delivery to the place of its consumption by service piping. Although pipes are generally laid below the frozen ground, this cannot be done in many cases for economic reasons. Engineering practice shows, however, that this exceedingly complicated problem has been solved in various ways.

As a rule regions with perpetually frozen grounds are sparsely populated, and the inhabitants of small places and villages are satisfied with the primitive water transport in barrels and buckets. But railroads crossing such territory badly need the installation of water services, so that Russian engineers were forced to do their utmost and find the way to satisfy the needs of the railroads.

First, special underground galleries have been built along the whole extension of water services to protect them against freezing; pipes were laid in these galleries that were heated either by stoves, by steam or by exhaust gases of steam-boilers, etc. Experience showed, however, that water services of this type require heavy expenditures for their maintenance and besides, they did not prove to be absolutely reliable.

A new suggestion has been made, therefore, that pipes be laid directly into the ground and be surrounded by special coatings; furthermore, the water is to be preheated before admission, which also prevents it from freezing in the pipes. But in order to operate such a water service, one must have a clear idea about the heat loss of water when it is passing through the piping and when it is in the pipes, thus enabling one to control the preheating, as well as to establish a certain general order of work.

In 1913 the writer experimented with water services especially laid

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into the frozen ground (upon request of the Building Department of the Amur Railway); the aim of the test was to find out the extent of the heat loss in the pipes.

By these tests it was found that the temperature of water in the pipes falls vigorously only immediately after it has been let in, but later on, when the metal pipe wall grows warm, too, there appeared thawed places in the ground surrounding the pipes. The thawed-out zone reduces the heat loss in the pipes, thus preventing water inside the pipes from freezing during the interruption of its circulation. No considerable preheating is required, so that it can be effected by the exhaust steam of the pump driving engine.

On the basis of these test-results we came to the conclusion that a new system of water-station equipment was necessary and adopted new methods of laying pipes in frozen grounds or grounds exposed to freezing.

The first water services of these new types "S" and "T" were built on the stations of Transbaikalian Railway. The equipment of water-stations is nearly the same as generally used for railway water-stations, with common plunger pumps. The only remarkable difference was in the preheater (which is used at the same time as a surface pipe condenser of the pump driving engine) arranged in the beginning of the pressure piping and the thermometers at the end of the water services.

The above-mentioned two water services were continuously studied with regard to the heat loss in the pipes.

#### "S" TYPE OF WATER SERVICE

Figure 1 shows a water service of the "S" type. The pressure piping consists of 100 mm.<sup>2</sup> diameter cast iron pipes having a total length of 930 meters. There is no distribution piping, and water is taken by locomotives out of a tank by means of an overhead water crane. Pipes are laid directly into the ground at a depth of 3 meters from the surface. The surrounding ground along the piping consists of clay on top, with change gradually into rubble and crushed rocks. Pipes are laid in the sphere that is frozen during the whole year. Its lowest temperature is  $-4.5^{\circ}\text{C}$ . The covering of the pipe is shown in figure 2. The piping has a certain slope and can be emptied by means of special fittings at the water-station.

<sup>2</sup> One meter equals 3.9 feet.—Editor.

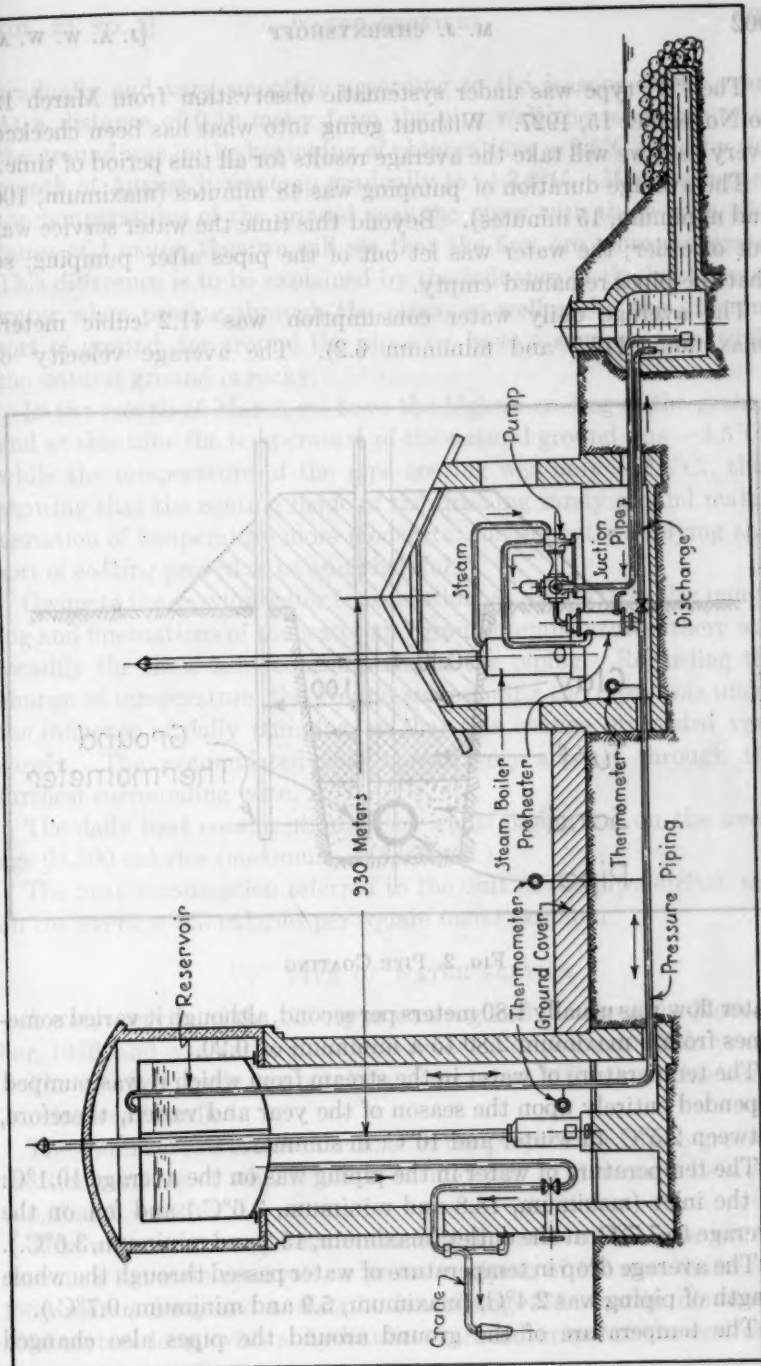


Fig. 1. THE "S" TYPE WATER SERVICE

The "S" type was under systematic observation from March 12 to November 15, 1927. Without going into what has been checked every day, we will take the average results for all this period of time.

The average duration of pumping was 48 minutes (maximum, 100 and minimum, 15 minutes). Beyond this time the water service was out of order; the water was let out of the pipes after pumping, so that the pipes remained empty.

The average daily water consumption was 41.2 cubic meters (maximum, 116.5 and minimum 6.2). The average velocity of

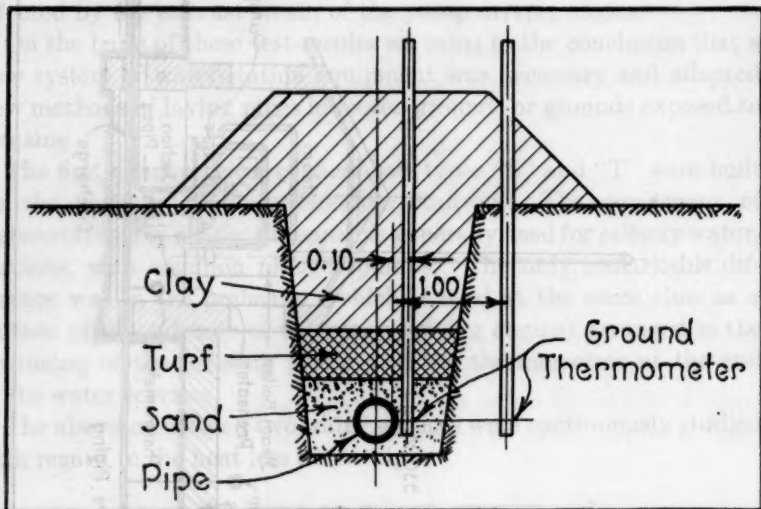


FIG. 2. PIPE COATING

water flow was usually 1.80 meters per second, although it varied sometimes from a maximum 2.80 to a minimum of 0.20.

The temperature of water in the stream from which it was pumped depended entirely upon the season of the year and varied, therefore, between 2.5°C. in winter and 16°C. in summer.

The temperature of water in the piping was on the average 10.1°C. at the inlet (maximum, 18.8 and minimum, 3.6°C.) and fell on the average to 7.7°C. at the outlet (maximum, 15.2 and minimum, 3.6°C.).

The average drop in temperature of water passed through the whole length of piping was 2.4°C. (maximum, 5.9 and minimum, 0.7°C.).

The temperature of the ground around the pipes also changed

gradually and very smoothly according to the seasons of the year. At a distance of 0.10 meter from the pipe wall the temperature of the ground was in the beginning of observations  $-2.5^{\circ}\text{C}.$ , and by the month of August it went up gradually to  $+3.6^{\circ}\text{C}.$  If we compare the temperatures of the ground near the pipes with those at a distance of 1 meter, then we will see that the first are more moderate. This difference is to be explained by the influence of the heat loss of water when passing through the pipes, as well as by the different sort of ground, for around the pipes we have a sand coating, while the natural ground is rocky.

In the month of March we have the highest cooling of the ground and at this time the temperature of the natural ground was  $-4.5^{\circ}\text{C}.$ , while the temperature of the pipe coating was only  $-2.4^{\circ}\text{C}.$ , thus showing that the coating made of the draining sandy ground makes variation of temperature more moderate; consequently applying this sort of coating proved to be quite helpful.

Owing to the varying water consumption, as well as irregular pumping and fluctuations of the water and ground temperatures, there was steadily the same heat consumption in the piping. Regarding the change of temperature, the ground surrounding the pipes was under the influence of daily pumping, so that this change proceeded very slowly. The accumulated heat spread very slightly through the furthest surrounding zone.

The daily heat consumption of the whole piping was on the average 93,500 calories (maximum, 518,000 cal.).

The heat consumption referred to the unit of the pipe surface was on the average 423 calories per square meter per hour.

#### "T" TYPE OF WATER SERVICE

A water service of the "T" type was regularly in use since November, 1916, and was under steady observation during one whole year.

The average yearly temperature of air is  $-3.3^{\circ}\text{C}.$  where this water service was installed.

The water service crosses the zone of the perpetually frozen ground, the temperature of which varies at a depth of 3 meters between  $-5.5^{\circ}$  and  $-3.2^{\circ}\text{C}.$

This water service system consists of a water collector, a water-station, a concrete reservoir, a pressure piping of 125 mm. diameter, 1880 meters long and a distribution piping 175 mm. in diameter, 1000 meters long, with a hydraulic overhead crane at the end and

a distribution station in the village. Figure 3 shows the general plan of this water service. The equipment of the water-station and the pipe coating are the same as those of the "S" type.

It is a characteristic of this pressure piping that water is running therein only when the pump is working, i.e., once a day. At all other times the water remains without any circulation. In the distribution piping the water circulates each time after the distribution, which occurs in short periods several times a day.

The following average data show the daily working of the water service. The duration of pumping was 3 hours, the water consumption was 100 cubic meters and the velocity of the water in the pressure piping was about 0.80 meter per second.

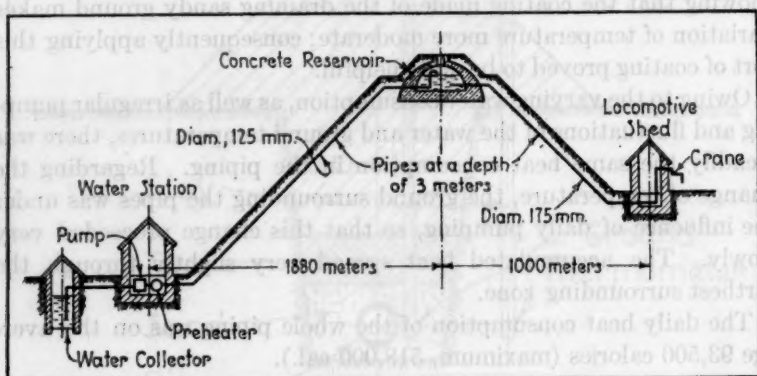


FIG. 3. THE "T" TYPE WATER SERVICE

Water is pumped out of a stream located under the perpetually frozen ground; the water temperature in the stream varies during the year between 0.5 and 1.2°C. The preheated water was admitted with an average temperature of 11.0°C. (maximum, 15°C. and minimum, 6.2°C.).

At the end of the pressure piping the water had an average temperature of 7.6°C. (maximum, 10.5 and minimum, 3.7°C.), thus showing that the drop in temperature of water passed through the whole extension of the pressure piping was only 3.4°C.

At the time when the pump was out of order, which lasted on an average of 21 hours per day, the temperature of water left in the pipes was on the average as follows:

|                                   | IN THE<br>BEGINNING<br>OF PERIOD | AT THE END<br>OF PERIOD | DROP IN<br>TEMPERA-<br>TURE DURING<br>THE<br>PERIOD |
|-----------------------------------|----------------------------------|-------------------------|---|
|                                   | °C.                              | °C.                     | °C.   |
| In the beginning of piping.....   | 11.4                             | 3.7                     | 7.7   |
| At the end of piping.....         | 8.4                              | 2.8                     | 5.6   |
| Average for the whole piping..... |                                  |                         | 6.7   |

The temperature of the ground at the depth of the pressure piping was as follows:

|                                    |              |
|------------------------------------|--------------|
|                                    | °C.          |
| At a distance of 0.10 meter.....   | +2.8 to +4.0 |
| At a distance of 0.30 meter.....   | +2.0 to +3.8 |
| At a distance of 10.00 meters..... | -5.0 to +1.4 |

The last thermometer showed that owing to the deformation of the upper ground layer near the piping the perpetually frozen zone settled deeper.

The average daily heat consumption in the pressure piping was 354,000 calories during the circulation of water and 156,000 calories for the period of rest, which makes in all 510,000 per day. The specific heat consumption was during the circulation 148.9 and during the rest 9.8 calories per square meter per hour, thus showing that the principal heat loss occurs during the circulation of water in the pipes.

The observed data referring to the distribution piping show that the drop in temperature of water in the reservoir, was on the average 0.7°C.; it came to the distribution pipes with a temperature of about 6.9°C. and reached the end with 4.3°C., thus showing an average fall of temperature of 2.6°C.

The temperatures of the ground as shown by thermometers put in the middle of the piping was as follows:

|                                  |              |
|----------------------------------|--------------|
|                                  | °C.          |
| At a distance of 0.1.....        | +3.5 to +5.0 |
| At a distance of 0.3 meter.....  | +2.8 to +4.4 |
| At a distance of 1.5 meters..... | -3.0 to +1.8 |

The heat consumption of the whole distribution piping was on the average 260,000 calories per day, and per unit of the pipe surface 19.7 calories per square meter per hour.

## DISCUSSION

Water services of both "S" and "T" type proved in practice to be quite suitable and reliable.

The "T" type, however, is to be preferred, because despite its considerable length, as well as severe conditions with regard to the temperature and the ground, and notwithstanding the short periods of daily pumping, this water service produced soon a rather considerable zone of thawed ground, yielding safe protection of the pipes against the coldness of the ground, due to the fact that water is permanently left in the pipes.

The water services of the "T" type give also a solution of the question regarding the distribution system, making the same simple and convenient.

Later on this type of water service was used throughout the frozen zone territory.

On the basis of the experience the following practical rules were adopted as to the construction of the distribution water works and their parts:

- (1) Too long branches leading to single buildings with a small water consumption are to be avoided owing to the risk of freezing. If it is absolutely necessary to lay such branch pipings, the pipes should be duly insulated by jute and paper coating and surrounded by dry saw-dust or turf.
- (2) The water-cocks installed for house use in front of buildings are to be made directly on the water service pipes and covered with heated sentry-boxes.
- (3) The water supply for railroad locomotives is to be arranged near the locomotive-sheds or water-reservoir buildings, etc. Water is to be supplied by means of overhead cranes or underground hydrants of the fire-pump type.

When starting a new water service a considerable quantity of water was put into circulation in order to preheat the zone of the ground surrounding the pipes.

Then a certain reduction of the water temperature in the pipes was permitted when the ground was already warmed-up. Thereupon a certain régime was established in an experimental way on the maintenance of piping, and the water service was transferred to the care of the attendance staff, whose qualification was exactly the same as for all other railway water-stations.

The attendance on water services of the above description is nearly

the same as on all usual water services with steam-pumps. Only one special duty is to be added, namely, to watch the temperature in the pipes, and in case of considerable drop, to let new quantities of preheated water pass through the pipes. The practice shows, however, that this measure is mostly applied when starting a new water service. Later on it can be dispensed with to a certain extent because of the gradual improvement of the heat conditions of the ground.

#### CALCULATIONS OF HEAT LOSS

When designing such a water service one must determine to what extent water should be preheated before admission to the pipes as well as the proper size of the preheater to be chosen. The preheater calculation does not produce any difficulties, as this can be done in the same way as designing surface condensers, so that we will not touch upon this question now.

But the heat loss of water in the pipes surrounded by frozen ground is according to our test-results influenced by the velocity of the water flow, by the difference in temperature between the water and the ground and by the kind of ground. The temperature of air affects the temperature of the ground at the depth of the pipes with a delay of 4 to 5 months and only to a very small extent. It permits us, therefore, to ignore its influence upon the water temperature in the pipes. Consequently, the process of heat loss in the pipes might be considered only as a propagation of heat from the pipes to the surrounding ground.

Inasmuch as the law of heat propagation in hard bodies (grounds) is not yet definitely settled, the exact determination of real heat loss at any moment is impossible.

In this case we adopted the empirical method of calculation, based on the average statistical data of continuous observations. This method can be applied only in particular cases when the conditions are similar to those of our observations, on the basis of which we determine the value of heat loss per unit of surface.

The following symbols were adopted for our formula:

$M$  = water consumption in the piping in liters per hour.

$T$  = Temperature in degrees Centigrade (generally).

$T_1$  and  $T_2$  = water temperatures in the beginning and at the end piping during the circulation.

$T'$  and  $T''$  = water temperatures in the beginning and at the end of the non-circulation period at any section, unless it is exactly indicated  $T_1'$ ,  $T_1''$ ,  $T_2'$ ,  $T_2''$ , which means in the beginning and at the end of the piping.

$t$  = natural temperature of the ground at the depth of pipes.

$Q$  = heat consumption of piping in calories per hour.

$q$  = heat loss in the pipes in calories per square meter of surface per hour.

$K$  = coefficient of heat loss in calories per square meter of surface per hour for  $1^\circ\text{C}$ . difference in temperature between water and ground.

$d$  = diameter of pipes in meters.

$l$  = length of pipes in meters.

$Z$  = duration of the interruption of water circulation in hours.

$e$  = base natural logarithms = 2.718.

$\pi$  = 3.14.

The coefficient of heat loss can be shown by the formula:

$$K = \frac{q}{T - t} \quad (1)$$

As the temperature of the ground changes very often and varies with the extent of the water preheating, duration of pumping and velocity of flow, which can be hardly expressed in mathematical form, we consider that it is more convenient to adopt in this case the natural temperature of the ground at the depth of pipes. This temperature can be at a distance of 1 to 2 meters from the pipes and can be determined by a ground-thermometer before laying the pipes, or by the data of the local meteorological station.

From our test-results we have the coefficient of heat loss for cast iron piping in clay grounds at a depth of 3 meters under the following conditions:

|   | Values of<br>$K$ |
|---|------------------|
| (1) At the inlet of the first portion of water into the cold pipes with a velocity of not less than 1 meter per second..... | 90               |
| (2) During the regular work of pressure piping permanently filled with water:   |                  |
| (a) During the circulation.....   | 18               |
| (b) When not circulating.....   | 1                |
| (3) During the regular work of the distribution piping with the average daily velocity of flow.....                         | 4                |
| (4) During the regular work of pressure piping, if same is emptied after pumping.....                                       | 52               |

The change of water temperature in the piping occurs in different ways, namely, during the circulation (if we have always the same kind of the ground) the water temperature falls gradually from the beginning to the end of the piping, remaining more or less steady with regard to the time of observation at any section; during the rest (when not in circulation) the fall of temperature is subject to the length of piping and to the time of observation. That is why the calculation for both of these cases is made separately.

During the circulation of water the heat loss on the whole extension of piping is determined by the formula:

$$Q = \gamma \cdot c \cdot M (T_1 - T_2)$$

where  $\gamma$  = the weight of 1 liter of water in kilograms and  $c$  = specific heat of water.

As in this case  $\gamma = 1$ , and  $c = 1$ , our formula will be:

$$Q = M (T_1 - T_2) \quad (2)$$

The lost heat delivered through the pipe walls can be expressed in the other way:

$$Q = \pi \, dlq \quad (3)$$

Along the whole piping we have different temperatures from  $T_1$  to  $T_2$  changing as per logarithmic curve. The difference between the average temperature of water in the piping and the temperature of the ground will be

$$T - t = \frac{T_1 - T_2}{\ln \frac{T_1 - t}{T_2 - t}} \quad (4)$$

From the foregoing we obtain the equation:

$$M(T_1 - T_2) = \pi \, dlK \frac{T_1 - T_2}{\ln \frac{T_1 - t}{T_2 - t}} \quad (5)$$

from which we have:

$$\ln \frac{T_1 - t}{T_2 - t} = \frac{\pi \, dlK}{M} \quad (6)$$

Substituting the right-hand side of this equation by  $\alpha$ , we have:

$$\alpha = \frac{\pi d L K}{M} \quad (7)$$

Then the temperature of water when it is let into the piping can be determined by the formula:

$$T_1 = (T_2 - t) e^{\alpha} + t \quad (8)$$

If water does not circulate in the pipes, the heat loss per unit of the pipe surface and on the infinitely small length can be obtained from the formula:

$$q = \frac{250 \cdot d}{Z} (T' - T'') \quad (9)$$

The difference in temperature between the water and the ground can likewise be obtained from the formula (4), so that we have:

$$q = K \frac{T' - T''}{\ln \frac{T' - t}{T'' - t}} \quad (10)$$

From these two formula (9) and (10) we obtain the equation:

$$\ln \frac{T' - t}{T'' - t} = \frac{Z \cdot K}{250 d} \quad (11)$$

substituting by

$$\beta = \frac{Z \cdot K}{250 d} \quad (12)$$

we obtain the formula determining the water temperature in the beginning of the non-circulation period:

$$T' = (T'' - t) e^{\beta} + t \quad (13)$$

If we have the minimum water temperature at the end of the non-circulation period and at the end of the extension of piping, then the water temperature at the inlet and in the beginning of piping can be determined by observation, thus we have:

$$T_2 = T'_2 = (T''_2 - t) e^{\beta} + t \quad (14)$$

Combining this equation with the formula (8), we obtain:

$$T_1 = (T_2 - t)e^{\alpha + \beta} - te^{\alpha} + t \quad (15)$$

The calculation can be made for each piping to be examined during its regular work, as well as when starting the water service, i.e., when its pipes are cold, thus requiring the most heat loss of water.

When a water service has been already started, and water has been let in for the first time, the maximum temperature at the end of the piping can be rather surely determined as

$$T = \text{from } 1^{\circ} \text{ to } 2^{\circ} \text{ C.}$$

Such temperature will be at the end of the piping only at the first moment when the water reaches the outlet; after continued strong pumping when the metal pipe walls become warm the water temperature will increase gradually.

During the regular work the water temperature at the end of the piping by ending of the non-circulation period can be considered as

$$T = \text{from } 3^{\circ} \text{ to } 5^{\circ} \text{ C.}$$

The coefficient of heat loss during the non-circulation period is very small, and, if we take into consideration that water becomes converted into ice at  $0^{\circ}\text{C.}$  after the loss of latent heat, we may say that the above-mentioned temperatures are more than sufficient to prevent the water service from freezing for several hours after the expiration of non-circulation period.

Of course, the above method of calculation cannot be considered as an absolutely safe and universal one, but still it can be used for approximate calculation in certain cases of practice.

## THE PREPARATION OF WATER FOR RAILROAD USE<sup>1</sup>

By C. H. KOYL<sup>2</sup>

Twenty years ago the sum of the knowledge of railroad men on the subject of water for boilers was that most waters free from mineral salts of every kind were good for boilers, that water containing dissolved salts of calcium or magnesium was objectionable because it would deposit scale in boilers, and that all other kinds of water were objectionable because the boilers using them either leaked or foamed or pitted or did all three. Why a boiler leaked was understood by few, and why a boiler foamed or pitted was understood by none. Of course, there was a great deal of wise talk, but it was all talk and guesswork.

Such has been the progress in twenty years that today there need be no scale or leaking in any boiler. We know the cause and the conditions of pitting, and have three workable methods of reducing and frequently preventing it. We do not yet know all the factors that contribute to foaming, but we know the two principal ones and are fast developing methods for lessening and sometimes preventing it.

### HISTORY OF WATER SOFTENING ON AMERICAN RAILROADS

The first recorded work in this country on the prevention of scale by softening the water before it reached the boiler was done by a committee of the American Railway Master Mechanics Association in 1870. This committee learned from the Professor of Chemistry in Illinois State University how water might be softened in the laboratory and they urged the railroads to operate the method on a large scale, but the state of the art of water softening in the country was so undeveloped at the time that nothing practical was done for more than twenty years.

<sup>1</sup> Presented before the Missouri Valley Section meeting, November 6, 1929, and the Illinois Section meeting, April 23, 1930.

<sup>2</sup> Engineer, Water Service, Chicago, Milwaukee, St. Paul and Pacific Railroad, Chicago, Ill.

According to our record, the first plant for water softening on an American railroad was installed December 10, 1891 on the Oregon Short Line Division of the Union Pacific Railway, and the second was installed in December, 1896 on the Southern Pacific Railway at Port Los Angeles, these both being "intermittent" plants.

The first "continuous" lime-soda water softening plant on an American railroad was installed by the writer on the Rio Grande Western Railway at Helper, Utah, in the year 1900.

Since 1900 the installation of water softening plants on railroads has progressed steadily, most of the plants being of necessity on the north-western roads where there is less good boiler water than on the eastern and southern roads. In 1910 there were about 100 lime-soda plants in operation for locomotive use, and the amount of water softened daily about 10 million gallons; in 1920 at least 400 plants and 40 million gallons daily; in 1928, 900 plants and 120 million gallons daily. In addition, another 120 million gallons daily are being treated with soda-ash or by the zeolite method. The total number of water stations on railroads in the United States is not far from 9000 and the daily amount of water used 900 million gallons.

There is a great difference in operating conditions between water softening for a municipality and water softening at the isolated tanks of a railroad. In the former case, where nearly all operations can be made automatic, the accuracy of treatment depends on the efficiency of the automatic appliances and can be relied on where there are skilled mechanics in attendance, but at the wayside tanks of a railroad, and particularly in the northwestern country where the population is sparse and skilled mechanics practically unknown, the fewer automatic appliances the better.

Notwithstanding the cost of operating these small plants, using from 15,000 gallons per day up, we find that it pays. The business of a railroad is to move trains on time and as economically as possible, the locomotive is the moving power of the train, the boiler is the heart of the locomotive, and good water is just as essential to a boiler as good blood to the heart of a man.

#### BOILER LEAKING

Boiler leaking, in nearly all cases, is the result of scale near the ends of the flues where they enter the firebox flue sheet. A flue covered with scale cannot easily transmit its heat to the water, and consequently gets hotter than normal and expands in the flue sheet. If

now the scale is loosened from any cause, or even if the boiler temperature drops a few degrees, the flue is no longer tight in the sheet and water oozes through into the firebox.

This leaking is the cause of most of the extra coal consumption found in boilers with scale. On the C. M. St. P. and P. R. R. when I began building water softening plants in 1920 and on the I. and D. Division east of Mitchell, S. D., there was a very bad water taken from the river at Canton, S. D. This river carried the sewage of Sioux Falls and in winter carried little else. The water caused immediate leaking in every locomotive which took it, and I completed the plant at Canton first. Within one week of starting this plant in operation all leaking had disappeared on that engine district, and when the coal records were made up there was found a perpendicular drop of twenty percent in coal consumption for that month. When all the softening plants on that engine district were working and the boilers were all clean, we found a further gradual drop of 10 percent in coal.

#### BOILER PITTING

The problems of scale and leaking having been solved, we attacked next the subject of boiler pitting and under-water corrosion in general, but in this matter I think that future generations will say that we were very slow. As far back as 1903 the fundamental reactions of under-water corrosion were worked out and announced by the research chemists of the Massachusetts Institute of Technology. By 1910 these statements had been examined and substantiated by many able chemists, but the information did not seem to reach the railroads.

To be as brief as possible, the statement of the chemists was that the purest iron will dissolve to a small extent in the purest water, that the atoms of iron which leave a flue in the process of making a pit all dissolve in the surrounding water and each atom carries with it its electric charge; that no electrically-charged atom (ion) can enter water in solution without expelling from solution at some other point an electrically charged atom of weaker solution tendency; that the only substance in solution in ordinary water which has a lower solution tendency than iron is hydrogen, and that therefore iron can dissolve in water only when it can force out a corresponding number of electrically charged hydrogen atoms, or ions.

This at once gives us the key to the prevention of pitting. It is easy to see that if iron cannot dissolve in water unless it can expel hydrogen

ions, all we have to do is to prevent the escape of hydrogen ions and we prevent the pitting.

It is also easy to see that, if we can rid the water of hydrogen ions by some inexpensive method, *that* is the simplest means of preventing corrosion, because if there are no hydrogen ions in the water there is nothing for the iron to push out, and the iron cannot dissolve. Now it happens that the presence of caustic soda in water prevents to that extent the presence of hydrogen ions, and the amount of caustic soda necessary is easily within the limits that can be carried in boiler water that is soft. It seldom exceeds 15 grains per gallon as the water goes to the boiler, and seldom exceeds 80 grains per gallon as the water becomes concentrated by continued evaporation. On the Great Northern Railway this is the method used and it has almost annihilated pitting on that road. Of course, it costs something to add 15 grains per gallon of caustic soda to boiler water, but it is cheaper than to repair the ravages of pitting.

When the hydrogen ions, or electrified hydrogen atoms, are pushed out of solution they gather in the form of a film on the iron surface which is not pitting, each hydrogen ion having given up its electric charge to the iron merely by touching it, and if there is any method of preventing the hydrogen ions giving up their electric charge they will remain ions and cannot be pushed out of solution in the water. On the Chicago and Alton Railroad, the chemical engineer has devised a very ingenious method of doing this. He coats the inside of the boiler with metallic arsenic whose electric properties are such that hydrogen ions cannot give up their electric charge to it, and therefore they remain in the water as ions, and the iron cannot dissolve because it cannot push them out. This method has been in use on the Chicago & Alton for four years and is now being extended to other roads. This method also costs perhaps fifty dollars per locomotive per year, but that is cheaper than pitting.

The third method was devised and proved by myself and I consider it the best because it costs nothing and actually saves money in locomotive operation. You will remember how the hydrogen ions, expelled from the water by the dissolving iron, gather on the other parts of the boiler interior, give up their electric charge to the iron (becoming thus mere molecular hydrogen), and cling to the iron because they are too small to float away, thus gradually but quickly forming a gaseous film over the cathodic iron surface, which protects it from the approach of the hydrogen ions which are being pushed to-

ward it from the anodic surfaces where pitting is going on. It is easy to see that such a film, one of the natural products of the first pitting, will prevent further pitting by preventing the further escape of hydrogen ions. But this protection does not last, because the oxygen which is dissolved in all waters which have been exposed to the air combines chemically with the hydrogen and destroys the film. But also the extraction of this dissolved oxygen before the feedwater reaches the boiler is all that is necessary to the permanence of the protecting film of hydrogen, and to the prevention of pitting. All we did was to attach to the outside of the locomotive boiler an "open" feedwater heater so constructed that the cold water from the engine tank is pumped into one side of the cast iron box in a fine spray to meet the exhaust steam from the cylinders (which ordinarily goes to waste in the atmosphere), becomes heated thereby to a temperature of about 220° and therefore gives up its dissolved air to the half-inch vent pipe which rises from the top of the box.

Some of you will remember that in a stationary boiler and its connections it is necessary that the dissolved oxygen in the feedwater be reduced to 0.05 cc. per liter to prevent corrosion. But conditions in a locomotive boiler are different because of the surging of the water and the tumultuous boiling, which is ten times as rapid as in a stationary boiler, and it was estimated and proved in a four years' test on the Sioux City Division of the Chicago, Milwaukee, St. Paul and Pacific Railroad that an average reduction of oxygen to 1 cc. per liter is sufficient.

This Sioux City Division has been our worst pitting district, for with natural waters the life of a set of flues used to average less than one year, with treated waters the average life was two years, but the engine with the open feedwater heater had not a pit at the end of four years.

The reason I say this is the best method of preventing pitting is that by utilizing the exhaust steam to heat the feedwater we save about 10 percent of the coal and water. A locomotive of average size uses about \$20,000 in coal per year, and therefore while we are preventing pitting by this method we are also saving \$2,000 in coal per engine per year.

#### FOAMING

Foaming in a locomotive is principally an operating difficulty, that is, it weakens the power of the engine, but it seldom injures the boiler.

For many years we have wondered whether the matter suspended in the water in the boiler or the sodium salts dissolved in the water are the primary cause of foaming, because we know that both are factors. But at last we have concluded that it is the matter in suspension, and if you have not studied the subject you will be surprised when I explain that it is because dirty water is stronger than clean water.

You know that if you sprinkle water on a clean floor the water spreads almost uniformly over the floor. This is because the cohesion of the water particles among themselves, which is sufficient to keep the water in the form of round drops when it is falling through the air, is not sufficient to keep the water in drops against the cohesion between the water and the floor. But if the floor is covered with dust you notice that the water remains as round drops coated with the dust, this because the skin surrounding the drop is made up partly of water and partly of dust and this skin is strong enough to hold the inclosed water against the attraction of the floor.

One of our railroad water engineers tells how, in 1918, he was testing the size of soap bubbles which he could blow from an inverted pipe bowl, and he discovered that dirty water made larger bubbles than clean water, because the thin skin of water surrounding the inclosed air was stronger if the water was dirty; and he announced in the A. R. E. A. Report of 1919 "Foaming is due primarily to the presence of suspended matter in the water. The suspended matter gives a mechanical strength or tenacity to the liquid in the thin films encasing the steam bubbles, which, rising to the surface, retain their films and collect to produce foam." And about this time a witty and facetious man labeled these large and dirty bubbles "armored froth," but they are generally called "stabilized films."

Now consider the water in a working boiler. Bubbles of steam are being continuously formed and given off from the heating surfaces. These bubbles of steam are rising steadily to the surface of the water and, if the water is clean and reasonably pure, the bubble-skins break easily and the steam escapes to the upper part of the boiler almost dry.

But if there is dirt in the water, such as finely divided scale or sludge from a softening plant, then the particles of dirt are mixed with the water to its very surface and some of them are in the thin film of water which surrounds each bubble of steam, so that the bubbles accumulate on the water surface and get so high in the boiler that, when they do break, some of the water goes over with the steam.

And a still worse effect is that, by clogging the surface of the water,

the bubbles appear to prevent the speedy issue of other bubbles, so that the water is gradually filled with bubbles and the surface rises, leading the engineman to believe that he has a boiler of solid water when he has only a boiler of froth.

### *Prevention of foaming*

Lastly, why does this foam disappear when a little castor oil is admitted to the boiler? If you allow a few small drops of castor oil to rise through a glass of dirty water you will find that the little drops of oil have stolen from the water much more than their share of dirt, and this greater affinity of dirt for oil than for water explains why a little castor oil on the surface of the water steals away the dirt from the steam bubbles and allows them to break promptly and to release practically dry steam.

## THE WELL DRILLER AND THE WATERWORKS FIELD<sup>1</sup>

A. G. FIEDLER<sup>2</sup>

In considering the facts that about half of the people of the United States use water supplied by wells and that about three-fourths of the cities and villages which have waterworks draw upon underground supplies, it becomes apparent that the water-well driller is engaged in a business that is intimately associated with the health and well-being of the public. It is estimated that there are about 8,000 cities and villages in the United States which have public waterworks. About 6,000 of these are supplied by wells. The largest well system in the country is the one which formerly supplied most of the water for Brooklyn, before that city became a part of the greater New York. It has a capacity of about 100,000,000 gallons a day. Many of the smaller systems, which supply innumerable villages scattered throughout the country, have a daily capacity of only 100,000 gallons or even less. Altogether about 17,000,000 people are supplied by public waterworks which derive their supply from wells. It is, therefore, likewise apparent that the work of the well driller is closely related to that of the men of the waterworks field, for without the skill and the effort of the well driller, many of these municipalities would probably be without a public water-supply system or would have to use other, more costly sources of supply.

Unlike many other kinds of work, the drilling of water wells is not covered specifically in any courses of study available in our schools, although in recent years several of the technical schools are giving some attention to the subject of well drilling in conjunction with their courses in petroleum engineering. Those of you who are interested in this subject have doubtless learned that the literature dealing with water-well drilling is extremely meager and inadequate. This condition is particularly noticeable in the journals issued by the technical

<sup>1</sup> Presented before the joint meeting of the Indiana Water Well Drillers and the Indiana Section, March 21, 1930. Published with the permission of the Director of the United States Geological Survey.

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societies, such as THE JOURNAL of the American Water Works Association and the Proceedings of the American Society of Civil Engineers, although both of these organizations have a large number of members who are more or less directly interested in the subject of ground-water supplies. In some respects this situation is peculiar in this day, when practically any other subject that is as old as well drilling has been treated at great length in many volumes. As a result the well driller has built up his knowledge of the art he practices simply by acquiring experience through years in the actual operation of drilling.

There are about 20,000 drillers in the United States, of whom probably more than 10,000 are actively engaged in the business. During an average year many thousands of wells are drilled, representing an expenditure of many millions of dollars. Although the number of wells drilled, especially for municipal water supplies, represents probably less than five percent of the total number drilled each year, yet these wells involve a much greater percentage of the annual expenditure because they are generally of more than average size and depth. Unfortunately no complete survey of the well-drilling business has even been made, and it is difficult, therefore, to make a reliable estimate of the extent of so widespread a business.

The men engaged in well drilling have much in common with the members of the waterworks profession. By reason of the fact that the ultimate goal of both is the same—namely, that of furnishing an abundant and convenient supply of pure water to the people—the well driller can appreciate some of the difficulties of the waterworks man in getting the water delivered to the ultimate consumer. Contrary to the conception which prevails in some quarters, the business of drilling wells is not without its difficulties and hazards. In fact, this business has more than its just share of hazards of failure, because the driller must conduct his work from the surface while his tools are working away unseen several hundred or thousand feet beneath the surface. Under such conditions many circumstances can arise that can ruin the patient work of many days and threaten the completion of the job. Because of these extra hazards, which are an integral part of the business, the experience of the man behind the drilling machine is especially important.

As an illustration of some of the difficulties encountered in deep-well construction I may mention that recently one of the deepest cable-tool fishing jobs on record was being done in a well at a depth of 9,379 feet. Although this particular job arose during the construc-

tion of an oil well and was done at a much greater depth than that usually involved in water-well construction, it is a rather impressive illustration of the fact that the drilling of wells is a highly technical business, requiring men of skill and mechanical training.

Even in an area that has been thoroughly explored by other wells, which have disclosed the character, thickness, and water-bearing properties of the different formations, the problem of obtaining additional supplies of ground water is not necessarily a simple one, although such information in regard to any locality is indeed of great value. In the final analysis the driller's task is to construct the well in such a manner that it will not only make a sufficient quantity of water of suitable quality available, but also yield the greatest quantity of water at the least expense.

This fact suggests a most important point, which is generally overlooked by engineers and water-supply men in the specifications for the construction of a well. Usually the specifications are centered around the quantity of water to be obtained from the well, and no mention is made of the equally important feature of drawdown. In view of the fact that, within certain limits, the yield of a well increases according to the drawdown, it becomes evident that the rate of yield alone gives insufficient information for judging the capacity of a well and that the amount of drawdown or the specific capacity of the well should also be given. For instance, if a well yields 250 gallons a minute under a drawdown of 10 feet, its specific capacity or rate of yield per unit of drawdown is 25 gallons a minute per foot of drawdown. By doubling the drawdown the yield is also practically doubled, and so on. It is evident, therefore, that the yield from any well could be increased by installing a pump of greater capacity, but because the drawdown would become greater under such increased yield the cost of pumping at the increased capacity might be prohibitive.

The specific capacity of a well that ends in creviced or fissured rock can not be controlled to any great extent by the driller, because it is governed largely by the number and size of the crevices that are encountered by the drill, but the specific capacity of a well ending in gravel and sand can generally be greatly increased through proper methods of development. This problem is gradually receiving increased attention by engineers and water-supply men, for it has a vital bearing on the economical operation of the water-supply system. The qualified well driller also realizes the importance of drawdown

and will gladly assume the responsibility of obtaining the greatest possible specific capacity if he is properly recompensed for constructing a well of high efficiency.

In the smaller municipalities, where detailed geologic examinations have not been made, the problem of determining the feasibility of using a ground-water supply or of obtaining an additional supply is frequently placed largely with the well driller. In territory in which the ground water is contained in the joints and crevices of hard rock wells of small yield are not uncommon. Where the ground water occurs in the interstices of unconsolidated material the driller is confronted with the problem of separating the water from the sand—a task which may be very difficult, but which if properly done may result in wells of large capacity. Other difficulties may arise in attempting to drill a straight hole through beds that are tilted at a high angle or to carry the hole through beds of quicksand that readily heave into the pipe. All these problems are constantly being encountered in the construction of wells, and their solution requires the exercise of great ingenuity and patience.

The elements of skill and experience, together with adequate equipment, play a vital part in the successful completion of work of this character. Although the usual run of drilling difficulties are to be expected in any job, at times unforeseen troubles may occur and seriously interfere with the early completion of a well project. These difficulties fall chiefly in the class of "fishing jobs." They involve the recovery of tools that have been lost in the hole, the removal of defective pipe or casing, and the recovery of tools that have wedged fast and can not be readily withdrawn. Many of these difficulties can be avoided by the use of good equipment and the exercise of skill in handling tools, but even the most skilled operators are not immune from them.

It can therefore be readily seen that the well driller is confronted by many problems and difficulties which can not be fully anticipated when the specifications for a well job are drawn up. Obviously it is unfair to require the driller to guarantee a given quantity of water under specifications that state in detail the methods and manner in which a well shall be constructed, without permitting him to exercise his own judgment on problems of construction.

There are three particular fields in conjunction with ground-water supplies in which the driller can be of real assistance to the water-works man. One of these fields has to do with the quantity of the

water, another with the quality, and the third with the method of constructing and finishing the well.

Most growing communities are confronted by a recurring problem of a shortage of water supply. Favorable location in reference to transportation, topographic features, and a prosperous surrounding country may provide conditions that would promote a marked increase in the growth and wealth of the community, but without an adequate water supply of suitable quality to take care of such expansion the prospects for continued development are greatly curtailed. Because the larger cities require such enormous quantities of water to satisfy their needs, they are continually having to go farther afield to obtain adequate supplies—many of them now going 50 or 100 miles or even more than 200 miles. The expense of such an undertaking is far beyond the capacity of the small municipalities, and of necessity they are limited to supplies that are closer at hand. An adequate source of surface water may not be readily available, or the expense of treating the surface water in order to make it fit for domestic use may be great, so that attention is given to the possibility of developing an adequate ground-water supply. Under such circumstances the driller can make a real contribution to the welfare of the community, for by means of test drilling or literally prospecting for water, just as the valuable minerals of the earth are prospected for, he may be able to locate ground-water supplies that have previously been passed by unnoticed or considered inadequate.

The demand for water of low mineral content is a problem that confronts many of our municipalities today. Large quantities of water that will be satisfactory for boiler use are required, and the selection of sites for plants engaged in special manufacturing processes is largely based upon the availability of a water supply of high quality. Increasing attention is also being given to the hardness of water used for domestic supply, because soft water in the home results in material savings in the consumption of soap and is otherwise much more satisfactory for domestic use.

The value of the services of the well driller in obtaining a water supply of higher quality are well illustrated by the results of work done in the vicinity of Canton, South Dakota, where soft water was discovered by the drillers in the Dakota sandstone and where formerly the supply had been obtained from terrace gravel that yield very hard water.

The third named field in which the driller can be of particular

assistance to the waterworks man is more or less closely related to the problems of quantity and quality. It involves not only the hardness, but also the sanitary quality of the water, for the method of constructing and finishing that is used has a vital bearing upon the problem of preserving the original purity of the supply.

I have been informed that considerable trouble has been experienced in this State with contaminated water from shallow depths running down the outside of the casing into the well. The usual methods of preventing such contaminated water from entering the well at the top of the casing, by tight sealing and a concrete platform or covering are relatively simple in application, but where they are not effective the problem is largely one of sealing the casing beneath the surface so that contaminated water can not percolate from one formation to another and hence enter the well. Cement is an excellent material for this purpose, and fortunately satisfactory methods have been developed for adapting it to the needs of water-well construction. Practically all the methods of cementing wells have been developed in the drilling of oil wells, where difficult water problems are frequent, although none of them are more important than the problem encountered in water wells of protecting the purity of water used for domestic supply.

In water-well construction where cementing materials are not used, objectionable waters in overlying beds are normally excluded by seating the casing in a relatively hard and impervious stratum, thereby shutting them off. Where this is impossible packers are frequently used, but in view of the fact that the packing material is normally subject to deterioration this method is not recommended for the best type of construction. In wells drilled by the rotary method heavy mud-laden fluid is circulated behind the casing and serves a beneficial purpose in preventing percolation of water behind the casing and in delaying deterioration resulting from the action of corrosive waters. In many localities it is impossible to find a hard and impervious formation upon which to set the casing and it is thus difficult to prevent the percolation of water along the casing and into the well. Under such conditions cement properly applied will prevent the entrance of the contaminating waters.

Three methods of cementing wells<sup>3</sup> are in use—the dump-bailer method, either with or without the use of “cement plugs;” the tubing

<sup>3</sup> For detailed discussion of cementing methods see: Fiedler, A. G. *Use of Cement in Well Construction: Water Works Engineering*, May 8, 1929, pp. 587, 588, 620, 623.

method, without plug or with one plug; and the casing method, with plug above and below cement or without plugs.

The dump-bailer method of cementing is probably the simplest and requires the least amount of special equipment. In this method cement is placed in the bottom of a well with a dump bailer after the casing has been raised from its seat. The casing is then lowered after it has been filled with water and sealed or the lower end has been closed with a suitable plug. As the casing is lowered the cement is forced up on the outside of the pipe and is permitted to set.

In the tubing method the cement is pumped into the well through tubing after circulation has been established. To prevent the cement from rising between the tubing and the casing suitable packing devices are used. The tubing method may be used either with or without a plug between the cement and the wash water that is pumped into the well to carry the cement up on the outside of the casing.

The casing method is more or less a variation of the tubing method and practically amounts to using the casing itself instead of the tubing. This method may also be used either in conjunction with one or two plugs between the cement and the water or without suitable barriers separating the cement and the water.

Asphalt has not yet been widely used for sealing water wells, but this material offers a special advantage in sealing wells that yield water under artesian pressure. In using cement the movement of the water must first be prevented, as otherwise the cement will wash away and will not form a tight seal. Asphalt, however, even before it sets, is impervious to water. When the heated asphalt comes in contact with water the outside of the material takes a partial set while the inside portion remains in a more or less fluid state. By controlling the temperature and the pressure under which the asphalt is placed, openings which contain water in motion can be tightly sealed, thereby preventing the entrance of pollution into the well or the loss of water under artesian pressure.

It would appear that some of these methods might be used to good advantage in Indiana and would largely prevent the contamination of waters of good quality. Some of them can also be adapted to overcome contamination in wells that have been completed for some time. Every such well, however, must be considered as an individual problem, and thorough study should be given to all the factors that bear upon its solution.

## THE DETERMINATION OF UREA IN WATER

BY M. H. McCrady<sup>1</sup>

The detection of excretal contamination of water supplies by means of chemical tests for specific substances contained in excreta has been the subject of frequent speculation by laboratory workers. The difficulties involved in the elaboration of tests of this character, chief of which is the requirement of great sensitivity because of the minute amounts of the test substances which may be present in even rather highly polluted water, have prevented much progress in this direction. But with the discovery of new reagents and more precise methods it is not unreasonable to hope that, in time, this goal of the water analyst may be satisfactorily attained. The purpose of the present paper is to describe one effort in this direction, an attempt to devise a simple method for the estimation of urea in water, and to discuss briefly the relative utility of some of the specific chemical tests which have been suggested for detection of excretal pollution of water supplies.

It is not surprising that urea,  $(\text{NH}_4)_2\text{CO}$ , which is contained in practically all the fluids of mammals and particularly in considerable amount (about 3 percent) in the urine of man, has been frequently suggested as a specific indicator of excretal contamination. Thus, Neave and Buswell (3): "if the water is polluted by sewage so recently that the urea has not been entirely hydrolyzed . . . the application to such water of a method for the determination of urea alone, would give absolute evidence of sewage pollution." The utility of the classic "Free Ammonia" method in water analysis is largely dependent upon the long-recognized fact that the urea in urine is readily converted by natural agents to ammonium carbonate. But a very sensitive test for urea, applicable to water analysis, has been wanting. Coupled with this lack of method there has been an uncertainty regarding the fate of urea when dissociated from the body, a question whether the urea might be so rapidly hydrolyzed as to nullify its utility as a specific indicator.

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The discovery, by Takeuchi (1) that certain legumes contain an enzyme, urease, which effects the conversion of urea to ammonium carbonate, and the rapid development of stable preparations of the enzyme from this source were quickly adapted by biological chemists to the estimation of urea in blood and urine. A variety of methods for this purpose are in use, consisting usually in incubation of the prepared sample with urease, liberation of the ammonia from the ammonium carbonate thus produced by means of alkali and aeration of the ammonia into acid where the amount of ammonia is determined by nesslerization or by titration of excess acid.

#### ADAPTATION OF UREASE METHOD TO WATER ANALYSIS

Two difficulties were encountered in the attempt to adapt the urease methods of the biological chemist to the estimation of urea in water: very small amounts of ammonia were not recovered by aeration with the usual types of apparatus, and consistently low blank ammonia readings were not obtained. Wette (2), in his study of urea in swimming pools, attempted to overcome these difficulties by means of a rather complicated modification and enlargement of the usual apparatus which would hardly be adaptable to routine work. And it is difficult to judge of the precision obtainable with his apparatus, for, working with considerable amounts of urea, his blank determination with the urease required, was of the order of 0.040mg.  $\text{NH}_3$ . When it is considered that the water analyst is concerned with quantities of ammonia of the order of 0.002 mg., it is evident that simple apparatus and a minimum of added reagents are imperative, if contamination by ammonia from extraneous sources is to be avoided.

Finally, aeration methods were abandoned and an attempt was made to distil, by means of heat, both the ammonia in the original sample and that resulting from action of the urease on the urea. But not without some misgivings, for it was feared that, by boiling the original sample to drive off free ammonia, significant loss of urea by hydrolysis might result, and that distillation might effect a significant conversion of other contained organic substances to ammonia. The studies of Neave and Buswell (3) on nitrogen determinations in sewage analysis indicated a considerable loss of urea from some samples of sewage upon boiling, but they were working with comparatively large amounts of urea, and the inference of loss of urea was derived indirectly from other determinations. On the other hand, Phelps (4) found only the small loss of 2 percent of urea upon distillation.

To obtain direct evidence on the effect of boiling dilute urea solutions, a series of tests were performed as described below:

a. To freshly boiled tap water urea was added, the solution made alkaline with sodium carbonate, and the free ammonia determined in the usual manner. Typical results follow:

| UREA NITROGEN ADDED | AMMONIA NITROGEN RECOVERED |
|---------------------|----------------------------|
| mg.                 | mg.                        |
| 0.020               | 0.000                      |
| 0.200               | 0.000                      |

b. Similar solutions of urea were made distinctly acid with sulphuric acid and boiled for 15 minutes, then made alkaline and distilled. The results were quite different from those previously obtained:

| UREA NITROGEN ADDED | AMMONIA NITROGEN RECOVERED |
|---------------------|----------------------------|
| mg.                 | mg.                        |
| 0.020               | 0.004                      |
| 0.100               | 0.012                      |

These results indicated that no measurable hydrolysis of the urea occurred upon distillation of solutions of the concentration indicated, except when the solutions were acidified. No doubt more concentrated solutions do suffer some hydrolysis, but concentrations which the water analyst is likely to encounter are apparently not affected by the free ammonia procedure.

c. As a matter of interest, some of the solutions used in (a) above were subjected to the usual albuminoid ammonia process, with the results indicated:

| UREA NITROGEN ADDED | ALBUMINOID AMMONIA NITROGEN RECOVERED |
|---------------------|---------------------------------------|
| mg.                 | mg.                                   |
| 0.020               | 0.000                                 |
| 0.200               | 0.006 (uncompleted)                   |

With the small amount of urea (0.020 mg. N) present which might occur in a well water, even this drastic procedure was without effect. The greater concentration, however, yielded 0.003 mg. in the first 50 cc. of distillate and the same in the second 50 cc. The determination was not completed for it is common knowledge that larger amounts of urea will yield albuminoid ammonia continually for some time. It is interesting to note that Phelps (4) found 4 percent of urea nitrogen to be evolved as albuminoid ammonia.

With reference to the second question, that of the effect of boiling upon organic constituents other than urea which may be contained in the sample, it may be recalled that the "free ammonia" procedure is readily carried to the end where no further ammonia is evolved. Moreover, Davisson (5) working with comparatively large amounts of readily decomposable pure organic substances and soil extracts found only moderate percentages of decomposition upon distillation with  $MgO$ .

In consequence, it is reasonable to expect that the preliminary boiling to liberate free ammonia from the sample will have the further effect of carrying to practical completion any measurable decomposition of such contained organic constituents. As a matter of fact, in the course of the work here described, waters of various degrees of pollution have been subjected to distillation subsequent to preliminary boiling with never a trace of ammonia resulting. It should be noted, however, that these tests were conducted on samples of 200 to 500 cc. to which only 1 cc. of  $N/10$  sodium carbonate had been added to alkalize the sample. It is possible that the presence of large amounts of alkali might have yielded different results. But to drive off free ammonia only a slight alkalinity is required. Standard methods require an alkaline reaction to methyl orange or a pH of over 4.0. Few water samples will require more than 1 cc. of  $N/10$   $Na_2CO_3$ , for boiling alone will usually increase the pH through elimination of free and half-bound  $CO_2$ .

If it be assumed, in view of the above considerations, that preliminary boiling of the sample, alkalized as described, has no effect upon small concentrations of urea and that the effect, if any, of such heating upon other contained organic constituents is carried to practical completion, the way is cleared for a distillation adaptation of the urease method for determination of urea in water. The next step, after driving off free ammonia in this manner, is the preparation of the solution for the action of the urease. Fortunately, the action of urease proceeds over a rather wide pH range. Lovgren (6) states that the optimum pH is dependent upon the concentration of the urea and, for small concentrations such as are here considered, gives the optimum as pH 7.8 or 7.9. Other authorities suggest figures varying from 7.0 to 7.5. But the action proceeds rapidly over a considerable range and probably any pH from 6.0 to 9.5, approximately, will prove satisfactory. In consequence simple neutralization of the alkalinity added for the preliminary boiling with 1 cc.

N/10HCl and a further short period of boiling to complete the neutralization and drive off  $\text{CO}_2$  should leave the sample in a condition favourable to the action of the urease. Most waters will be somewhat alkaline in character after this treatment.

The most convenient form in which urease may be employed is that of the dry tablets, such as the 25 mg. Urease-Dunning tablets, and considerable experimental work was done to determine precisely the manner in which they should be used. Employing a volume of 50 cc. urea solution, it was found that very small amounts of the urease preparation sufficed to convert reasonable quantities of urea to ammonium carbonate. But an unexpected relation was encountered in this connection. Using a solution of 2 tablets crushed in 15 cc. distilled water, 1 cc. converted 0.020 mg. urea nitrogen contained in 50 cc. water almost quantitatively; but if only 0.006 or 0.008 mg. urea nitrogen were present, no conversion occurred. But if 2 cc. of the urease solution were used, even the small quantity of 0.004 mg. urea nitrogen yielded at least 0.002 mg. ammonia nitrogen. In other words, greater sensitivity was obtained with the larger amount of urease.

But this increase in the amount of urease employed cannot be carried too far because the urease preparation will, itself, yield some ammonia upon distillation and, in order to detect slight differences between the blank and the sample ammonia contents the amount of urease must be limited to yield only a trace of ammonia in the blank determination.

Three different lots of Urease-Dunning tablets purchased from three different dealers have been tested with remarkably consistent results. Two cubic centimeters of solutions prepared as described above have yielded, upon distillation with 300 cc. ammonia-free water to which 1 cc. N/10  $\text{Na}_2\text{CO}_3$  had been added, blank readings of ammonia nitrogen never greater than 0.003 and seldom less than 0.002 mg. As it is a simple matter to detect the difference between the Nessler reading of 0.003 and the reading of 0.005 mg. of ammonia nitrogen this quantity of 2 cc. of the urease solution was adopted for the procedure finally elaborated; it permits detection of as little as 0.004 mg. urea nitrogen and determination, practically quantitatively, of amounts varying from 0.004 to at least 0.200 mg. urea nitrogen.

The incubation temperature most favorable to the urease reaction appears to be about  $50^\circ$  or  $55^\circ\text{C}$ ., a period of one hour being sufficient. The ordinary  $37^\circ$  incubator was used for some tests with quite

satisfactory results, but most of the work here described was done with an electric oven operated at from 50° to 55°C.

After incubation with urease, the sample is added to ammonia-free water alkalized with 1 cc.  $N/10$   $Na_2CO_3$  and distilled in the usual manner to obtain the ammonia.

#### DETAILS OF PROPOSED METHOD

##### 1. Reagents and apparatus

(a) Crush 2 Urease-Dunning tablets (25 mg. tablets) in 15 cc. ammonia-free distilled water.

Solution should be freshly prepared just before use.

(b)  $N/10$   $Na_2CO_3$  made up with ammonia-free water.

(c)  $N/10$  HCl made up with ammonia-free water.

(d) Glass-stoppered bottles of about 60 cc. capacity, flasks.

(e) Free ammonia apparatus, standards and reagents.

##### 2. Procedure

Place sample of 200 to 500 cc. in flask, add 1 cc. of the  $Na_2CO_3$  solution, and boil rapidly down to a volume of about 100 cc. If a small quantity of sample, as of sewage, is to be examined, make up to 200 cc. with distilled water and proceed as indicated.

Add 1 cc. of the HCl solution, shake to rinse walls of flask, and continue boiling to a volume of 50 cc.

Shake to rinse walls of flask, cool and transfer to glass-stoppered bottle of about 60 cc. capacity. Add 2 cc. of the urease solution, stopper bottle tightly and incubate at, preferably, 50° to 55°C. for one hour (a 37°C. incubator may be used).

During the incubation the still may be prepared. Place about 450 cc. distilled water in the distilling flask, add 1 cc. of the  $Na_2CO_3$  solution (and a small piece of ignited pumice to prevent bumping) and distil about 150 cc. to remove ammonia.

Pour the incubated sample into the ammonia-free water in the flask thus prepared and distil as in the free ammonia determination. Nesslerize the distillates and, after 10 minutes, compare with ammonia standards in the usual manner.

A blank, using distilled water and 2 cc. of the urease solution should be distilled in a similar manner and the ammonia nitrogen reading subtracted from that obtained with the sample.

##### Notes

It is convenient to have the boiling flasks marked with a wax pencil at 100 cc. volume and at 50 cc. volume, the distilling flasks at 450 cc. volume and the beakers for waste distillate at 150 cc. volume.

Boiling flasks should be rinsed with strong HCl after each boiling, for the scale which gradually forms on the walls and bottoms of the flasks appears to

exert an inhibiting influence on the urease reaction which follows. It is for this reason that the urea solution is transferred to bottles for incubation with the urease.

The distilling flasks need only be rinsed with distilled water after use, and occasionally thoroughly cleaned. A deposit from the urease preparation gradually accumulates on the walls of these flasks.

As traces of Nessler's Solution inactivate the urease, care must be taken to avoid contamination of boiling flasks and incubation bottles by this solution.

Maharg stills, with mercury seal, have been found very satisfactory for this work, as they readily and consistently yield zero blanks and are very simply operated. Regardless of the type of still employed, it is advisable to slip a disk of rubber sheeting of about an inch in diameter over the delivery tube of the condenser to prevent dust from the apparatus and condensation water from the outside of the condenser from entering the Nessler tubes. In humid weather, contamination from the latter source may prove very troublesome.

Urea solution for testing the described procedure is conveniently prepared as follows:

Dissolve 0.0536 gram of urea in 100 cc. distilled water.

Make up 8 cc. of this solution to 200 cc. with distilled water. One cubic centimeter of this final solution contains 0.010 mg. of urea nitrogen.

Water for testing the method should not contain residual chlorine for chlorine inactivates the urease.

#### RESULTS WITH PREPARED UREA SOLUTIONS

The method described was tested with three waters: distilled water, Montreal tap water and Quebec tap water. Montreal tap water is derived principally from the St. Lawrence River and, when the tests to be detailed were made, had an alkalinity of 85 p.p.m., a color of 10 and a pH of 7.5. Quebec tap water is derived from the St. Charles River. It had an alkalinity of 12, a color of 35 and a pH of 6.7. Varying quantities of urea were added to these waters and examined by the method described. The results are shown in table 1.

It will be noticed that the limit of sensitivity was about 0.004 mg. urea nitrogen. Less than this amount fails to yield an ammonia reading sufficiently greater than the blank (0.002 to 0.003) to be readily detected.

Particular attention is directed to the tests with 0.004 mg. urea nitrogen when contained in a sample of 200 cc. and when contained in 1000 cc. Despite the long-continued boiling to reduce the larger volume of sample to 50 cc., the same result was obtained as with the smaller volume of sample.

It is evident that there is usually a slight deficiency in urea nitrogen recovered, of about 0.001 or 0.002 mg., but for all practical purposes the method yields reasonably quantitative results.

THE COMPARATIVE UTILITY OF CERTAIN SPECIFIC TESTS FOR  
EXCRETAL POLLUTION

In the examination of waters for sanitary purposes, the remarkable sensitivity of the bacteriological tests usually employed has made them justly popular among laboratory workers. But cases occasionally occur where the information derived from such tests does not suffice. Considerable difference of opinion exists regarding the relative significance which should be attached to the presence in water of the various organisms of the coli-aerogenes group. And in the examination of ground water, the problem of interpretation is further complicated by the possibility of elimination of bacteria by filtration through the

TABLE 1  
*Tests for urea in water*

| WATER SAMPLE     | UREA N<br>ADDED | AMMONIA<br>N* RE-<br>COVERED | WATER SAMPLE   | UREA N<br>ADDED | AMMONIA<br>N* RE-<br>COVERED |
|------------------|-----------------|------------------------------|----------------|-----------------|------------------------------|
| cc.              | mg.             | mg.                          | cc.            | mg.             | mg.                          |
| 200 distilled    | 0.000           | 0.003                        | 200 distilled  | 0.008           | 0.010                        |
| 200 Montreal tap | 0.000           | 0.0025                       | 200 Quebec tap | 0.008           | 0.011                        |
| 200 Quebec tap   | 0.000           | 0.003                        | 200 distilled  | 0.010           | 0.012                        |
| 200 distilled    | 0.004           | 0.005                        | 200 Quebec tap | 0.010           | 0.011                        |
| 1000 distilled   | 0.004           | 0.005                        | 200 Quebec tap | 0.020           | 0.020                        |
| 200 Montreal tap | 0.004           | 0.005                        | 200 distilled  | 0.030           | 0.030                        |
| 200 Quebec tap   | 0.004           | 0.005                        | 200 distilled  | 0.050           | 0.046                        |
| 200 distilled    | 0.005           | 0.007                        | 200 distilled  | 0.100           | 0.102                        |
| 200 distilled    | 0.007           | 0.009                        | 200 distilled  | 0.200           | 0.204                        |
| 200 Quebec tap   | 0.007           | 0.008                        |                |                 |                              |

\* Blank not subtracted.

soil or substrata, though the water may yet be subject to dangerous potential pollution. The occasional need of differentiating between surface wash and sewage pollution is not always satisfied by the results obtained from the bacterial tests.

There is thus a place for chemical tests for excretal pollution. At present many laboratories depend, in such instances, upon the classic nitrogen determinations, and, where discretion is employed in the interpretation of the results obtained, these serve a useful purpose; but it must be admitted that they are not entirely satisfactory since the substances determined are not specific of excretal or even sewage pollution.

Three substances have been suggested as possible specific indicators for excretal pollution: Indican by Jolles (10), phenol by Theriault (7), and urea. According to various authors, these occur in the discharges of the average human adult in the quantities indicated:

|              | mg. per day |
|--------------|-------------|
| Indican..... | 12          |
| Phenol.....  | 200         |
| Urea.....    | 32,000      |

If the above quantities are reduced by one-half to represent the average per capita of the general population, the content of these substances in sewage, calculated on the basis of 100 gallons per capita per day of water consumption, works out approximately as shown:

|                    | Content in sewage<br>p.p.m. |
|--------------------|-----------------------------|
| Indican.....       | 0.015                       |
| Phenol.....        | 0.250                       |
| Urea nitrogen..... | 20.000                      |

In fact, Theriault (7) found the content of phenol in certain sewages to range from 0.10 to 0.50 p.p.m., and Neave and Buswell (3) found about 20 p.p.m. of Urea nitrogen in samples of sewage examined by them.

The sensitivity of the tests proposed for these various indicators may be taken as shown below, the figures given indicating the minimum quantity of the substances which must be present in 500 cc. of the sample to yield, upon concentration, positive results by the methods specified:

|  | mg.   |
|--|-------|
| Indican—Jolles Test.....                                   | 0.003 |
| Phenol—Gibbs method, modified by Baylis and Theriault..... | 0.005 |
| Urea—Method here described.....                            | 0.004 |

The sensitivity appears to be, in all cases, of the same order as that of the Nessler test for ammonia.

Calculating the dilutions of sewage with pure water necessary to reduce the content of these indicators in 500 cc. of the mixture to the above limits of sensitivity, the following results are obtained:

|              | Dilution of sewage for<br>500 cc. of dilution to yield<br>a positive test |
|--------------|---|
| Indican..... | 1:1.5   |
| Phenol.....  | 1:24  |
| Urea.....    | 1:2500  |

It appears that, working with 500 cc. of sample, (as a maximum for a routine laboratory test), the test for urea is the most practicable for the detection of small amounts of excretal pollution. The test for phenol might be used, as Theriault (7) suggests, to measure the pollution of very polluted waters, but here again the urea determination also may be employed, and probably to better advantage.

Two other questions, in addition to that of sensitivity of test, must be considered in the discussion of the relative utility of these substances as indicators: the possibility that they may be derived from sources other than excreta, and their fate when dissociated from the living organism. Phenol, as is well known, may be contained in the wastes from a variety of industrial processes and the analyst must be on the lookout for such sources when interpreting the results of tests for phenol. The writer is aware of no evidence to indicate that indican is not specific of excretal pollution, although it must be admitted that little investigation in this regard has been attempted. the same remark applies to urea as an indicator, though it is well to remember that the amino-acid, arginine, a decomposition product of animal and vegetable proteins may be converted to urea and other products by the enzyme, arginase, which occurs in some plants. To what extent this source of urea may affect the interpretation of results obtained from water examination is problematical. That it may not interfere seriously is indicated by the many negative results for urea obtained in this laboratory, in the examination of various waters containing much organic matter of obviously vegetable origin. Experience alone, however, will determine the validity of the present assumption of the specificity of urea as an excretal indicator.

As regards the fate of these indicators in water, the available data are again very meagre. Schmidt (8), discussing the Indican test, suggests the possibility of absorption of indican during its passage in water through soil and rock. Theriault (7), in his studies on the fate of phenol in water, found that "100 parts per billion of phenol will practically disappear from raw Ohio River water in one hour," and ascribes this effect "either to some peculiarity of the reagent or to some chemical reaction with the constituents of the water." It has been generally assumed that urea is very rapidly converted to ammonium carbonate by bacteria in the sewage or the soil. That this may be true under some conditions is quite possible, but that the conversion does not always proceed very rapidly is indicated by the following series of tests: a half-gallon sample of St. Lawrence River water taken some distance below a sewer outlet

was examined for urea a few hours after collection, then placed on a table in the laboratory and left there for eight days at room temperature. During this period several determinations of urea were made, 200 cc. of the sample being employed for each test:

| TIME AFTER COLLECTION OF SAMPLE | UREA NITROGEN IN 200 CC. OF SAMPLE |
|---------------------------------|------------------------------------|
| days                            | mg.                                |
| 0                               | 0.013                              |
| 1                               | 0.015                              |
| 2                               | 0.012                              |
| 8                               | 0.011                              |

Blanks, consisting of 200 cc. of the sample, but without the addition of urease, run in exactly the same manner as the determinations, at the beginning and end of the 8-day period, gave zero ammonia readings.

These results indicate that the conversion of the urea contained in this polluted water was not proceeding at a very rapid rate. The further fact that many of the examinations of well waters made in this laboratory have shown the presence of urea, suggests that the decomposition of urea in the soil and substrata may not always be effected so rapidly as to preclude its use as an indicator of excretal pollution.

Naturally, in a field where so little investigation has been attempted, future experience may considerably modify assumptions or conclusions which may be advanced at this time, but present indications point to the urea determination as a specific test which may prove of real utility in water pollution investigations. Urea occurs in human urine to the extent of about 3 percent, in the urine of herbivora in a somewhat less proportion, and in that of certain birds and fishes in only a small amount, according to Hawk (9); it is apparently specific of such pollution; it persists, frequently at least, for a reasonable period in surface and ground waters; the method of determination of urea here proposed is sensitive and capable of considerable precision.

The determination of urea may prove of value (a) in the detection of excretal pollution of water, particularly that derived from underground sources; (b) in the determination of the degree of excretal pollution of water as opposed to pollution of other character; (c) in nitrogen studies on sewage.

Experience alone will determine the place of the urea test in sanitary water and sewage analysis. Much work will be necessary to establish, through correlation studies of urea findings and field survey and other findings, its ultimate utility. But the apparent specificity of urea as an indicator of excretal pollution, together with the possibility of its quantitative determination, combine to open a new field of investigation in water pollution which may prove of considerable interest.

#### SUMMARY

An adaptation of the urease method for the detection and determination of urea in water is proposed, capable of a sensitivity of the order of 0.004 mg. urea nitrogen.

The comparative utility of various specific tests for excretal pollution is briefly discussed.

The limited evidence available indicates that urea is specific of excretal pollution; that, when contained in water, it is not always rapidly converted to ammonium carbonate; and that, in consequence, it may prove useful as an indicator of the presence of excretal pollution in sanitary water analysis.

The writer gratefully acknowledges the valuable aid contributed by Léa Grenier, Assistant-Chemist in this Laboratory, who performed many of the determinations here described.

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## CHARGES FOR STANDBY, BREAKDOWN OR AUXILIARY SERVICE<sup>1</sup>

By J. C. STIPHER<sup>2</sup>

The natural laws governing the sale of water, gas, or electricity do not differ to any great extent from those of any other commercial enterprise, except in that the average commercial merchant is at liberty to bargain and sell with each consumer and is at liberty to discriminate in prices or methods.

The advantage of this right to bargain with each consumer is questionable, and representative business institutions have abandoned, or are gradually abandoning that policy and are adopting the policy under which public utilities by law are regulated.

The matter of proper charges for standby, breakdown or auxiliary service enter into and affect so materially the charges for other classes of service that it seems necessary to consider, at least in a general way, the principal factors entering into the entire rate structure. The result to be desired is not so much an increased or proper charge for consumers whose use of service is for a short duration, but to compensate for and encourage the use of the demand for a greater number of hours.

The effect of a maximum demand on a system is not the same with all utilities. A railroad company furnishes its service at stated hours, the telegraph company furnishes its service not instantly, but in the order in which messages are received for transmission, the telephone subscriber must wait until the connection is completed, whereas, there must be sufficient capacity ready at all times to supply gas, water and electricity, which must be delivered at the very moment the consumer chooses to use it, and for as long, and no longer, than he pleases to use it.

Accordingly, the central station and distribution system must be of sufficient size to meet the maximum load of the entire system. This is especially true in the matter of electric energy in that there is

<sup>1</sup> Presented before the Indiana Section meeting, March 20, 1930.

<sup>2</sup> Indianapolis Power and Light Company, Indianapolis, Ind.

no practical manner in which any large amount can be stored. It is evident, therefore, that the cost of serving should be governed by factors other than that of the actual energy used by each consumer. There are three recognized factors which should enter into the establishment of rates for service; namely, demand cost, output cost and consumers expense.

Demand cost is the fixed charges on the cost of that portion of station equipment, transmission lines, transformers or substations, real estate, buildings, etc., used and useful in supplying the maximum requirements of the consumer, also, a certain portion of the general expense, taxes and depreciation. In other words, it may be classed as rental charge for the equipment necessary to take care of the consumers maximum load.

Output cost is the cost of the energy used by the consumer and consists of the cost of fuel, oil, water, labor and supplies incidental to power-house operation.

Consumers expense is the cost of reading meters, billing and collection expense, new business and consumers premise expense.

In considering an adequate compensation for service, the charge rendered should, as far as practicable, bear a relation to the cost of rendering it. If it is a matter of competition it will solve itself, for a utility cannot long supply one class of consumers at a loss and recoup that loss by exorbitant profits from another class.

It is clearly to the advantage of the utility to obtain as its patrons those whom it best pays to serve and to provide such means as are practicable to compensate those consumers whose operations and usage are of benefit to the system of the utility. On the other hand, it is equally important to both the utility and its consumers that the utility receive a proper compensation from those consumers whose hours of operation are so short as to necessitate a capacity expense incommensurate with their usage.

Inasmuch as the central station cost is one composed largely of fixed charges and is not materially affected by the quantity of product sold, the cost of the product delivered to the consumer's premises is affected more by the hours' use of the maximum demand, or by the load factor, than by any other factor.

Prior, therefore, to the establishment or readjustment of rates, the utility ascertains the amount of interest and other fixed charges on the property and equipment used and useful in the supplying of service to its patrons. The fixed capital costs thus established are

allocated and distributed to the various classes of users on its system, using as a basis for such allocation its experience and records as to what percentage of such costs is chargeable to each particular class. Thus is established the demand cost, previously referred to.

The output cost and customers expense, the remaining factors which enter into the ultimate rate, are established in a like manner. Unlike the demand cost, however, these costs although averaged, would not reflect any great difference whether consumers were treated as a class or individually. This procedure is equitable to all concerned, in that proper consideration is given to diversity factor, or the ratio of the sum of the maximum demands of a given group of consumers at different times, to the actual maximum demand by the group at one time. At this time it may be well to emphasize the fact that the central station industry is dependent for its existence on diversity and demand factors.

There are many forms of rates in use throughout the country, with most of which you are familiar and which include as follows: flat rate (no meter), uniform meter rate (flat rate per unit of measurement), meter rate based on quantity of consumption, meter rate with a minimum charge, meter rate based on hours use of maximum rated capacity and rates varying with time of day at which service is used, etc.

All such rates are based upon the average operating conditions and average cost of serving a certain class of consumers. In other words, a class of consumers is considered and treated as a whole and the rate per unit of measurement or the block of the rate, as well as the minimum charge, are so constructed as to insure a fair and reasonable return to the utility.

Under such forms of rates the costs of serving, or fixed capital costs, are as a rule included in the first block of the rate. There are advantages and objections to all such forms of rates and you are familiar with them particularly as they relate to flat rates. The one objection to all is that the consumer whose operations are helpful to the system, must help carry the consumer whose operations are harmful and in some instances must help carry those who are served at a loss to the utility.

A rate schedule should have three primary objectives; first, to secure a satisfactory profit for the utility; second, to develop the sale of the product, by discouraging the use of private plans and other sources of supply, developing new uses for its products and improving

the load factor of its system by improving the load factor of its individual consumers. The third objective is to prevent discrimination by providing rates so constructed that each class of consumer, and, when practical, each consumer, will bear a proper share of central station costs.

Inasmuch as the demand cost, or as it is sometimes termed, the readiness to serve cost, is the principal factor in the cost of supplying gas, water and electricity and is not materially effected by an increased consumption, it should be given primary consideration in the establishment of rates for service. That this method of charging for service is practical is evidenced by a review of rate schedules of electric utilities, throughout the country.

At the present time the form of rate which comes the nearest to fulfilling the objectives referred to, is the demand or demand and energy rate.

The demand and energy form of rate, as the name implies, is composed of two distinct charges, a demand charge and an energy charge.

To participate in, or benefit by this form of rate, it is necessary that the operations of the consumer be such that his load factor, or hours use of his maximum or billing demand be greater than that of the average consumer, for if otherwise, the cost to him for such service would be less under a form of rate not having the demand charge feature.

There are a number of methods employed throughout the country in determining the demand and in establishing the demand charge. Some of these are as follows:

Demand as contracted for and limited by a demand limiter.

Demand based on rated capacity of consumers' equipment.

Demand based on rated capacity of transformers installed.

Demand based on instantaneous peak indicated by watt-hour meter or recorded by graphic instrument.

Demand based on integrating peak of 5, 10, 15, 30, etc., minutes duration, as shown by installed demand meters.

Demand based on average of two or more of the integrating peaks, referred to.

In analyzing these methods you will note that some would tend to curtail the size of the installation and thus retard further use and development, invite fraud, provide compensation for a demand, that may, but has not yet been required.

The intent of the method adopted should be to establish a charge

for service in the same manner that it would be determined if the consumer was installing a private plant of the exact size necessary to supply the demand created.

The last two methods: namely, demand based on integrating peaks of certain duration, and the average of such peaks, are the methods more generally employed at the present time.

If the method adopted for the determination of the demand involves the installation of demand meters, or entails added expense, the demand schedule should be protected by a minimum charge providing a sufficient amount to insure the costs of determining the necessary demand information.

The next angle involved in applying the demand schedule is as to whether the billing demand, once established, shall apply only during the month such demand was created, or shall it continue for twelve months or until exceeded by the demand of a subsequent month.

The basis of practically all business is annual, rather than monthly, and the manufacturer or merchant fixes the prices of the goods he sells on the basis of his annual overhead charges and costs of doing business and which apply in the good season, as well as in the bad.

In a case before that body the Public Service Commission of Indiana said:

In the operation of electric utilities it is also noteworthy that all electrical engineers of recognized ability recommend the kilowatt Demand Charge, which is in reality a Ready to Serve Charge applied to consumers of electric current, based on capacity required.

In the year 1924 this Commission made a very thorough investigation of the Ready to Serve, or Demand Charge applying to electric utilities, with a view of eliminating it, however, very weighty argument, by those familiar with its application succeeded in convincing the Commission of the fairness of the Demand, or Ready to Serve Charge and that it should not be disturbed."

In another case the same Commission defined the Measured or Billing Demand as the greatest average rate of consumption of electric energy used by a consumer for fifteen consecutive minutes within the period of one year.

The principle of this demand or ready to serve charge is not only universally recognized as being sound, but it has been repeatedly approved by state public service or utilities commissions throughout this country.

The prime purposes accomplished in the use of the demand and energy form of rate is that it insures a proper compensation for stand-

by, breakdown, or auxiliary service and thus enables the utility properly to compensate the consumer whose load factor rebounds to the betterment of the entire system.

In other words, the demand and energy form of rate places the consumer on his own feet and ultimate charges are commensurate with his operations.

The following example emphasizes the fairness of this form of rate:

"A" has connected and has in use coincidentally two 300 h.p. motors loaded to capacity and thereby establishing a demand on the company's system of  $(600 \text{ h.p.} \times 0.746 \text{ k.w.})$  447.6 kw. He uses this demand of 447.6 kw. one hour per day, establishing a daily consumption of 447.6 kwh. or  $(447.6 \times 360 \text{ days})$  161,136 kwh. per year.

"B" has connected and has in use coincidentally two 50 h.p. motors loaded to capacity and thereby establishing a demand on the company's system of  $(100 \text{ h.p.} \times 0.746 \text{ kw.})$  74.6 kw. He uses this demand of 74.6 kw. six hours per day establishing a daily consumption of  $(74.6 \times 6 \text{ hours})$  447.6 kwh. or  $(447.6 \text{ kwh.} \times 360 \text{ days})$  161,136 kwh. per year.

Accordingly, "A" has six times the demand of "B," but it is in use but one-sixth the number of hours that "B"'s demand is in use.

The total yearly consumption for each is identical, namely, 161,136 kwh. per year. The total yearly costs for electric service to each under a block energy rate would be the same, thus providing no incentive for a longer hours use of the demand and no penalty for an abnormal demand.

Under the demand and energy form of rate consumer "A" and "B" would pay the same amount for energy, but in addition each would pay a Ready to Serve, or Demand Charge, proportionate to the cost to the Utility supplying his demand requirements. The demand cost to "A" would be six times as great as the demand cost to "B," and this is as it should be.

In conclusion, an abstract from an opinion of the Public Service Commission of Indiana, in a case before that body, is pertinent.

While there are weeks and months in which many large users of electricity may not consume any current, it would be unjust and unfair to require the public utility to be prepared at all times to furnish them such service without applying the Ready to Serve Charge, known as the Kilowatt Demand, based on capacity."

## PUBLIC UTILITY ACCOUNTING IN THE CITY WATER DEPARTMENT<sup>1</sup>

BY R. D. MILLER<sup>2</sup>

The Public Service Commission has prescribed a uniform classification of accounts for water utilities, which deals with the accounting system in considerable detail. Obviously it would be impossible for me, in the limited time at my disposal, to refer to all accounts and follow each in all of its refinements. It will be my aim, therefore, to discuss only those accounts which the smaller utility is required to carry.

The classification of accounts divides utilities into two classes, class "A," embracing cities having a population of 3,000 or more, and class "B," having less than 3,000 population. The purpose of this division is to prescribe the minimum of accounts which may be carried by the smaller utilities. However, any utility may keep a more detailed classification than prescribed, going into as much sub-division or refinement of accounts as the interests of the utility seem to require, but no utility in either class may re-arrange or combine two or more of the prescribed accounts in such manner as to interfere with the integrity of the general scheme, or in any manner to violate the general principles of accounting.

There are two phases of accounting to be given consideration, which I will designate as Income and Expense Accounts, and Balance Sheet Accounts. The Income and Expense Accounts are susceptible of great refinement or sub-division, and the detail with which these shall be kept depends largely upon the size and scope of the utility. Since the Balance Sheet Accounts are generally fixed in character, and as we encounter less difficulty on the part of the small utility in the handling of these, I shall confine my remarks to the first division.

Income or revenue consists of two general classes—operating and non-operating.

Operating revenue is made up of commercial earnings, embracing

<sup>1</sup> Presented before the Montana Section meeting, April 18, 1930.

<sup>2</sup> Auditor, Public Service Commission, Butte, Mont.

both flat rate and metered service; industrial sales, covering both flat rate and metered service; municipal hydrant rentals; earnings from street sprinkling; sales to municipal departments, and miscellaneous earnings from operations.

In the event the contract with the municipality for hydrant rental includes the use of water for street sprinkling and flushing purposes the total revenue from these sources should be credited to the account Municipal Hydrant Rental.

The account Sales to Municipal Departments includes all revenues from the sale of water to departments other than for street sprinkling. For the smaller utility this may be embodied in the one account, but for the Class "A" utilities a separate account should be kept with each municipal department.

While we are on this subject it may be well to make special reference to the subject of hydrant rentals in connection with municipally-owned utilities. This matter has come before the Commission on several occasions. The Montana Commission, in line with the Commissions of other jurisdiction, has always maintained that a municipally-owned water utility acts in a proprietary, and not a governmental, capacity, and as such it is not justified in furnishing free service for street sprinkling, sewer flushing, park irrigation or fire protection. To do so means that the consumer pays, through excessive rates, not only the water actually consumed by him, but also for the water used by the city, whereas this burden should rest upon the shoulders of the tax payers generally. No one would contend that a privately-owned water utility should furnish free fire hydrant service to the city, and since the water utility owned by the municipality stands in exactly the same relation to its consumers as does the privately-owned utility, there can be no justification for furnishing fire hydrant service without a reasonable and fair revenue for such service. To do otherwise results in unlawful discrimination which is prohibited by the Public Service Commission Act. Then again, if the city is given free fire hydrant service the revenues of the utility fall short of the amount the utility is entitled to, and this in turn has a direct bearing upon the amount that it is possible to set aside for reserve funds.

We come now to the matter of Non-operating Revenues. These embrace the following: profit on merchandise sales, profit on piping and connections, rents from land, buildings and apparatus, interest on deposits, interest and dividends from investments, appropria-

tions from municipal funds (municipal plants only), miscellaneous non-operating revenue. For the class "B" utility these may all be included under the one head of Non-operating revenue.

Profit, as used in connection with merchandise sales, means the excess of sale price over the invoice cost, cost of freight, handling, storage, etc. All labor and materials used in connection with the sale of merchandise should be charged to this account, and the net amount, or profit, only should be carried to the Income Account.

Profit from piping and connections embraces the earnings from all services performed on the premises of consumers, less all expense for labor and materials used in connection therewith.

Charges and credits to these accounts should be kept with such detail as to admit of a complete analysis, when called for by the Commission.

Rents from land, buildings and apparatus means the revenues received from these sources, less all expenses in connection therewith, such as collection expenses, commissions and fees paid agents, cost of procuring tenants, drawing contracts, leases, advertising, taxes, etc. Only the net profit from these sources should be carried to the Income account, and entries should be made with sufficient detail to permit of complete analysis.

Interest on deposits includes interest received on all funds deposited with banks, trust companies or individuals. Interest received on security investments must be credited to the account Interest and Dividends on Investments. Interest received on funds belonging to any of the reserves must be credited to the appropriate reserve account.

Appropriations from municipal funds, as applying to municipally-owned plants, embraces all appropriations made for operation purposes.

Miscellaneous non-operating revenue embraces all revenues from non-operating sources not properly includible in the preceding accounts, and as in the other non-operating revenue accounts only the net amount should be carried to Income.

This brings us to the subject of Expense Accounts.

Operating expenses, in the broadest sense of the term, are divided into two classes, viz., Operation and Maintenance.

By "Operation" is understood the use of the property, including labor, materials and supplies, and the expenses incident to its operation, but does not include the maintenance of the property.

By "Maintenance" is meant the upkeep, and covers all ordinary repairs, replacements and renewals resulting through ordinary wear and tear, or casualties incident to the nature of the operation and which are necessary in order to keep the productive capacity of the plant to its original state of efficiency. This includes the cost of labor and salaries paid to those engaged in clerical, engineering and supervisory capacities; all materials and supplies used in making repairs including proper proportion of cost of preparing same for use, such as freight, storage charges, etc.

Hand tools, because of liability to loss and theft, are to be considered as supplies in the year in which purchased and chargeable to the account for the benefit of which they were purchased.

The account Commercial Expense embraces collection salaries and commissions, reading meters and delivering bills, collection supplies and expenses, such as stationery, stamps, etc. and surety bonds of collection department employees, uncollectible accounts (charge to reserve), promotion of business salaries and commissions, promotion of business supplies and expenses. All of the above, in the case of the class "B" utility would be charged under the one account, Commercial Expense.

General expense includes the salaries of general officers, whose jurisdiction extends over the entire business, and whose services are not chargeable to any particular department; salaries of general office clerks, except such as may be directly connected with some particular department. (In case a general office clerk devotes a part of his time to any particular department his salary should be apportioned accordingly; general office rent; miscellaneous general office supplies and expenses; legal expenses, except the salaries, fees and retainers for counsel and attorneys in defending settlement of injury and damage suits; miscellaneous general expenses, which includes all such items as publishing reports, notices of stockholders' meetings and other corporate and financial notices, traveling expenses, dues to associations, etc. Particular attention is directed to the fact that subscriptions, donations, gratuities and charities do not represent a charge to be borne by the consumer, and such payments must be made from Net Income, and in nowise included in Operating Expenses.

Maintenance of general office equipment, and general office buildings, fixtures and grounds, is also chargeable under the head of General Expenses.

Undistributed expense includes such items as injuries and damages,

insurance, stationery and printing, operation of stores department maintenance of stores department, maintenance of stores department buildings, fixtures and grounds, operation of utility equipment, maintenance of utility equipment, maintenance of utility equipment buildings, fixtures and grounds, depreciation, contingencies (extraordinary), taxes.

Under this heading I wish to call particular attention to the item of Depreciation, inasmuch as this is perhaps the least understood of any of the operating expense items. The classification of accounts provides that every utility shall carry a depreciation reserve account, to which shall be charged monthly (if the books are kept on an accrual basis) or annually an amount which will fairly represent the amount necessary to replace a unit or facility of plant after it has become irreparable or obsolete. Bear in mind that ordinary wear and tear necessitating repairs constitutes a maintenance charge. If, after a period of years, the unit is no longer repairable and it becomes necessary to replace it with a new unit the cost of such substitution is to be taken care of through the Depreciation Reserve Account. The monthly or annual depreciation charge is an operating expense and should be charged periodically to operation expense of the particular unit or facility of service, and a corresponding credit made to the Depreciation Reserve Account. There are a few utilities which make a charge for depreciation at a flat rate for the entire plant, but this is not good accounting, since all units of service do not depreciate uniformly. The rate of depreciation should be determined for each unit, and then, if it is desired to make but one charge for depreciation the equated rate for the entire plant should be used. Charges and credits to depreciation should be kept with sufficient detail to permit of complete analysis when called for. The Depreciation Reserve Account, as stated, is set up for the purpose of bearing the cost of substitution of a unit or facility of plant which has either become irreparable or obsolete. When the unit is discarded the salvage value of the old unit should be credited to Depreciation Reserve Account, and the cost of the new unit of equal capacity charged to the Depreciation Reserve Account. In the event the new unit is of appreciably greater capacity than the old unit the excess cost of the new unit over the old should be charged to plant and equipment account.

In closing I wish to make reference to only two of the Balance Sheet Accounts, viz., Depreciation Reserve Account, already referred to.

and Sinking Fund for the retirement of bonded indebtedness (municipal plants).

We often find that amounts which have been set apart out of operating revenue to the Depreciation Reserve have been appropriated for other uses than that of replacement of units of plant, such as new extensions or improvements. This is a practice which is subject to much criticism, and in support of this I quote from decision of the Commission in re Chinook Water Rates, M. U. R. 12, 358, as follows:

"Capital Costs. All capital, whether for original installation or subsequent extensions, should be provided by the vendor of the service, i.e., the municipal corporation as a legal person, and it is immaterial whether this capital is provided from the general fund or from the sale of securities issued directly against the utility, assuming such could be done, or whether the full faith and credit of the municipal corporation are pledged in water bonds. Capital is not to be furnished through water rates. In this jurisdiction the ordinary method (in the absence of funds on hand) is to issue bonds for the amount necessary for the construction or acquisition of the utility, with provision in the bonds that interest and principal are to be provided for by tax levies. Cities may, however, construct water plants by the issuance of bonds after their constitutional limit of indebtedness has been exceeded, under the extraordinary safety restriction that the city "Devote the revenues derived therefrom to the payment of the debt. Our Supreme Court has remarked, however, that this pledge of revenues does not imply a prohibition to make additional provision for payment by way of a tax levy. *Carlson v. City of Helena*, 39 Mont. 82, 102 Pac. 39 (Secs. 5039 and 5278-5288, R. C. M. 1921). It would seem therefore, that the capital outlay could still be amortized by a tax levy and interest charges defrayed through rates as contemplated."

The following applies with equal force to the privately-owned utility.

"New extensions and improvements to the extent that they add to the original value of the plant should be provided for directly from the general fund of the city or from the same sources as the original capital outlay. It often happens that new extensions are made by using the cash representing the offsetting assets for the depreciation reserve. In the case of a municipal utility, this postpones the time when the amount so used would have to be provided by the city, either through taxation or the sale of bonds. The investment in these extensions can be considered merely temporary, however, and when the time arrives when replacements are necessary and actual cash is needed for this purpose, the amount of cash required for such replacements must be provided by the city and the city equity increased proportionately. The city administrators should not yield to importunities which have for their object the dissipation of the depreciation reserve in new extensions."

Referring now to the matter of Sinking Fund for redemption of bonds and interest thereon, as it relates to the municipally owned utility, the Commission holds that revenues of the water department can not be used for this purpose except under certain specified conditions. If the bond issue is in excess of the three percent limit established by the first part of Sec. 6, Art. XIII of the Constitution, but authorized under the provision of the latter part of said Section 6, the revenues from the city owned plant are irrevocably set aside to the discharge of the principal and interest of such indebtedness, but if such revenues are insufficient the deficiency must be taken care of by proper tax levy. On the other hand, if the issue is within the three percent limitation referred to it becomes the ordinary obligation of the city and must be taken care of by direct taxation on property within the city, as authorized by Sec. 5283, R. C. 1921, "A tax to be fixed by ordinance must be levied each year for the purpose of paying interest on the bonds and to create a sinking fund for their redemption." In support of this position I quote from the case *Edwards v. City of Helena*, 58 Mont. 292, 191 Pac. 387, wherein the Court said

"It is a matter of vital consequence to the taxpayer whether the bonds are within or beyond the three percent limit. If they are beyond that limit, and authorized by Sec. 6, Art. XIII of the Constitution, the revenues from the city owned water plant are irrevocably set aside and dedicated to the discharge of the interest and principal, and a taxpayer who is not a water user may not be called upon to contribute anything, unless the water plant revenues are insufficient, and then only may a property tax be levied to supply the deficiency. On the other hand, if the margin within the three percent limit is sufficient to admit of a bond issue in the amount necessary, such bonds become the ordinary obligations of the city, to be redeemed by funds derived from direct taxes upon property within the city, unless other provisions are made for their payment and the payment of the interest as it becomes due.

"It does not appear from this record whether the city's water system was purchased by funds derived from the sale of bonds issued in excess of the three percent limit, but it is not material here. If the three percent limit was exceeded, the revenues from the water system are set apart to the discharge of that original indebtedness only to the extent that such revenues are necessary, and any excess is subject to disposition by the city council as other public revenues of the city (*McClintock v. City of Great Falls*, 53 Mont. 221, 163 Pac. 99). It is not claimed in this complaint that such revenues are not sufficient to meet the original indebtedness, and this new bond issue; and it follows that the excess may be employed to discharge this new indebtedness, and that, if any tax levy is ever required, it will be only such as is rendered necessary to meet the deficit."

I trust that in this brief and somewhat disconnected discussion I may have presented to you some points which will be of assistance to you in connection with the keeping of your records. As previously stated it would be impossible to cover the entire field of Water Department Accounting, but I have tried to present matters which, in the light of our experience, seem to constitute the most common difficulties.

By D. E. DAVIS, and J. T. CAMPBELL, in charge of the Ohio Valley Water Company, Inc., at Louisville, Ky.

Data on large scale operating experience with another softening plant have been somewhat meager, and it is with the purpose of making this store of information that this paper is offered. The data and comparisons have to do with the four million gallon pressure type softeners at the plant of the Ohio Valley Water Company at Louisville, Ky., and the two million gallon open softeners at the plant of the Louisville Water Company at Louisville, Ky. A description of the plant may be found in the July, 1928, issue of THE JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION.

The softening features and materials are briefly summarized in table I. The distinguishing differences between the two plants reside in the contrast between pressure and open type units. The open softeners at Louisville, being designed for use as filters as well as softeners, operate at usual filtration rates and correspond closely to rapid sand filtration practice as regards head losses, sand rates, etc. The pressure type softeners at the Ohio Valley Water Company operate at about twice the rate of the open filters, but require materially greater head, in the ratio of 22 to 5 feet. The open units permit ready and continuous observation of the process, which is difficult of accomplishment in the closed units, because of the design.

A wash rate up to 15 gallons per square foot per minute is possible without loss of sand on the open units, although (with the clean water handled) the rate of 7 gallons is found satisfactory. The closed type units have shown considerable losses at the recommended sand rates, and have been somewhat of a loss. This is probably due to the fact that their internal cross section and apertures are on the small side, the distance above the sand being which is of the order of 10 to 12 inches. The wash rate is therefore limited by the distance above the sand, which is of the order of 10 to 12 inches. The wash rate is therefore limited by the distance above the sand, which is of the order of 10 to 12 inches.

Presented before the Toronto Convention, June 27, 1928.  
The J. T. Campbell, President, and J. T. Campbell, Secretary, of the Ohio Valley Water Company, Inc., at Louisville, Ky.

## ZEOLITE SOFTENING PLANT OPERATING EXPERIENCES<sup>1</sup>

By D. E. DAVIS<sup>2</sup> AND J. T. CAMPBELL<sup>2</sup>

Data on large scale operating experiences with zeolite softening plants have been somewhat meager, and it is with the purpose of enlarging this store of information that this paper is offered. The data and comparisons have to do with the four million gallon pressure type softeners at the plant of the Ohio Valley Water Company about six miles below Pittsburgh, Pa., and the two million gallon open-softener type plant for the Borough of Sewickley, Pa. A description of the plants may be found in the July, 1929, issue of THE JOURNAL.

The salient features and contrasts are briefly summarized in table 1.

The distinguishing differences between the two plants reside in the contrasts between pressure and open type units. The open softeners at Sewickley, being designed for use as filters as well as softeners, operate at usual filtration rates and correspond closely to rapid sand filtration practice as regards head losses, sand rise, etc. The pressure type softeners at the Ohio Valley Water Company operate at about twice the rate of the open filters, but require materially greater head, in the ratio of 32 to 5 feet. The open units permit ready and continuous observation of the process, which is difficult of accomplishment in the closed units, because of the design.

A wash rate up to 13 gallons per square foot per minute is possible without loss of sand on the open units, although (with the clear water handled) the rate of 7 gallons is found satisfactory. The closed type units have shown considerable losses at the recommended six gallon rating, and have given some trouble at four. This is probably due to the fact that their circular cross section and cost considerations on the shell, limit the distance above the sand line at which the off-take pipe (corresponding to wash trough) can be placed. As the wash water rises it is compelled to converge toward the center at the upper

<sup>1</sup> Presented before the Toronto Convention, June 27, 1929.

<sup>2</sup> The J. N. Chester Engineers, Pittsburgh, Pa.

segment of the circular cross-section, thus relatively increasing the velocities. This fact, together with the short distance between sand and off-take, limits the wash rate and evidently makes it difficult to prevent some loss of sand. Experience thus far with the open units indicate that this difficulty has been obviated in that design, since no losses can be detected.

The sand cross-section in the open unit is rectangular, which is not quite true of the circular closed unit. Standard rate controllers are used on the open unit, whereas the closed unit passes the quan-

TABLE 1

| PLANT  | OHIO VALLEY<br>WATER COMPANY | BOROUGH OF<br>SEWICKLEY, PA. |
|--|------------------------------|------------------------------|
| Type.....  | Pressure                     | Open                         |
| Number of units.....   | 4                            | 4                            |
| Nominal cap. in gals. per 24 hours.....                        | 4,000,000                    | 2,000,000                    |
| Area per sand bed in sq. ft.....                               | 208                          | 181.5                        |
| Cubic feet of sand per unit.....                               | 670                          | 470                          |
| Direction of flow.....   | Downward                     | Downward                     |
| Rate of flow in gals. per sq. ft. per min....                  | 4.3                          | 2                            |
| Rate of flow control.....                                      | None                         | Rate control-<br>lers        |
| Wash rate in gals. per sq. ft. per min.....                    | 4 to 6                       | 6 to 13                      |
| Sand rise during wash in inches.....                           | 4.7 to 5.6                   | 5.6 to 18.5                  |
| Pound of salt per 1,000 grains removal....                     | 0.344                        | 0.334                        |
| Grains removal per cubic foot.....                             | 3250                         | 4004                         |
| Salt dose.....   | Variable                     | Constant                     |
| Grain characteristics—effective size in mm..                   | 0.31                         | 0.285                        |
| Uniformity coefficient.....                                    | 1.50                         | 1.50                         |
| Wash brine and rinse water in per cent of<br>plant output..... | 10.5                         | 6.5                          |
| Head, feet.....  | 32                           | 5                            |

tities which the available head loss imposes. In these two features, the open filter appears to advantage, in that the water (and brine solution) seems to travel with greater uniformity downward through the sand thus assuring the fullest regeneration of each sand particle and the maximum removal of hardness per cubic foot of sand.

Figure 1 presents a picture of the operating results since the Sewickley plant was started. The hardness of the water reaching the consumers was reduced gradually to 60 p.p.m. at which figure it has been maintained. This was accomplished by gradually softening the several

days reserve in the Borough reservoirs. There was evidently no difference in the taste between the hard and soft water,—at least no general comment has been voiced. Some complaints were expected, either for imaginary or real reasons. Accordingly precautions were taken for making daily bacteriological and chemical analyses on samples taken in the process steps from the crib through to the reservoir. So far as known, not a single complaint was made.

The plant has proved to be quite simple and fool-proof in operation. The zeolite filters are set at a constant rate of about two gallons per square foot per minute while the hard water filter is set at the approximate rate shown in the curve of figure 2. The second curve indicates

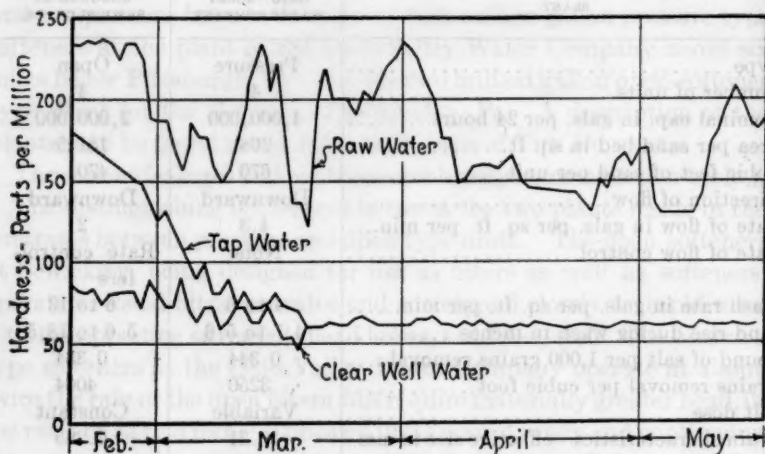


FIG. 1. OPERATING RESULTS, IN TERMS OF HARDNESS, AT SEWICKLEY, PA.

the period of run, and by following the procedure there set out, the final product is kept close to 60 p.p.m. as may be seen in figure 1.

The individual operation consists in turning the effluent of the newly regenerated softener into the soft water clear well, from which it proceeds to the mixed water clear well, there mingling with the hard water effluent from the hard water clear well. The operator usually checks (by soap method) and records the end of the soft water run, and of the "twilight zone," or period during which the zeolite bed completes its exhaustion of sodium, and the hardness changes from zero to that of the raw water. The latter part of the entire run usually involves the delivery of hard water through the bed. The

operator finishes the total run by closing the raw water valve, and pulling the water to within an inch or so of the sand. He then closes the effluent valve, presses the button to start the brine pump which delivers the brine solution over the bed, and then opens the rewash valve to a calibrated point so as to pull the brine down through the zeolite sand at a rate from 1.5 to 2.0 gallons per square foot per minute. After the brine solution approaches the sand line, the rewash valve is fully opened (to about a 3.2 gals. per square feet per minute rate), and also the influent valve.

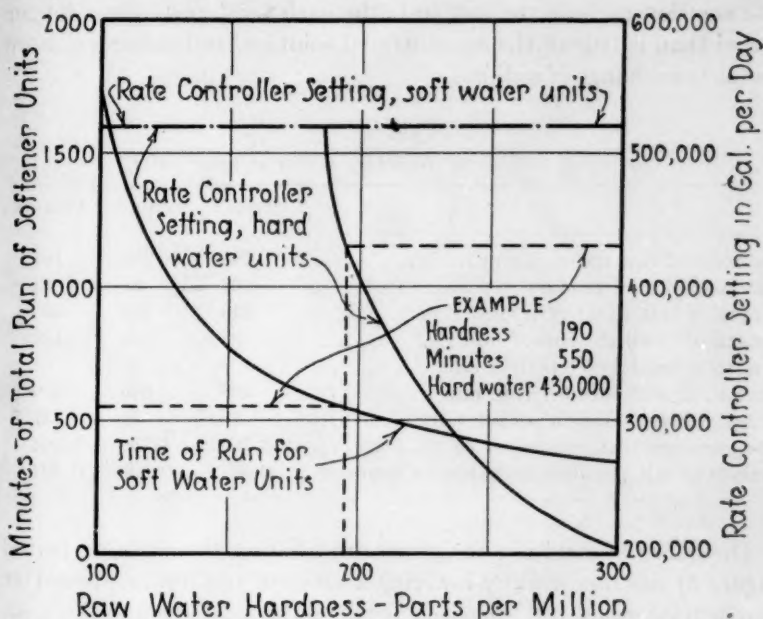


FIG. 2. CURVES FOR CONTROL OF OPERATIONS, SEWICKLEY, PA.

During this period of "rinsing" the waste chlorides are washed out to waste through the sewer. After a total elapsed period of approximately 35 minutes, the rinsing is pronounced complete, as determined by tests explained in figure 4, and the softener is started on another cycle.

Units have been back-washed on an average of once in 71 hours of service during which period the head on the softener units increases from 4.8 at the start to 7.2 at the end, contrasted to 2.9 and 6.4 for the hard water unit.

The record of 15 consecutive runs is shown in table 2.

During an earlier experimentation period the results for 38 observations indicated a removal of 3790 grains of hardness per cubic foot of green sand, and the salt dose 0.353 pound per 1000 grains removal.

This improvement has been effected by changing the dilution of the salt dose, while maintaining the same quantity of salt in all cases. In the earlier runs an 8.6 percent solution (by weight) was employed, whereas the latter regenerations have been made with a 5 percent solution. The apparent explanation of the result is that the more dilute solution permits the salt to bathe each sand grain for a longer period than is true of the concentrated solution, and induces a more complete exchange of sodium.

TABLE 2  
*Record of 15 runs on Sewickley zeolite softener units*

|  | MINIMUM | MAXIMUM | AVERAGE |
|--|---------|---------|---------|
| Hardness of raw water, p.p.m.....              | 185     | 210     | 194     |
| Hardness of final product, p.p.m.....          | 60      | 68      | 63      |
| Length of soft water run, min.....             | 345     | 460     | 398     |
| Length of "twilight zone," min.....            | 95      | 150     | 123     |
| Length of hard water period, min.....          | 0       | 60      | 38      |
| Length of total softener run, min.....         | 495     | 645     | 559     |
| Length of regeneration period, min.....        | 20      | 40      | 37.7    |
| Hardness removal, grains per cu. ft.....       | 3,700   | 4,330   | 4,004   |
| Pounds of salt per 1000 gr. hardness removed.. | 0.361   | 0.309   | 0.334   |

The curve of sand rise for green sand during the washing period (figure 3) was obtained by lowering a series of test tubes, spaced at two inch intervals, into the space between the sand line and the wash trough, and noting the rise from the sand line to the highest tube in which the sand appeared for each given rate. The curve seems to correspond closely with other observations on quartz sands of similar grain characteristics.

Certain technical data respecting the rinsing out of chlorides at the close of the regenerating period and of the action of the zeolite bed towards the end of the softening period are grouped in figure 4. At the start of the softening operation the fresh zeolite (or green sand), contains its maximum amount of sodium. As the "hard" water passes through the bed, an ionic exchange takes place through mass action such that the calcium and magnesium in the water "switch

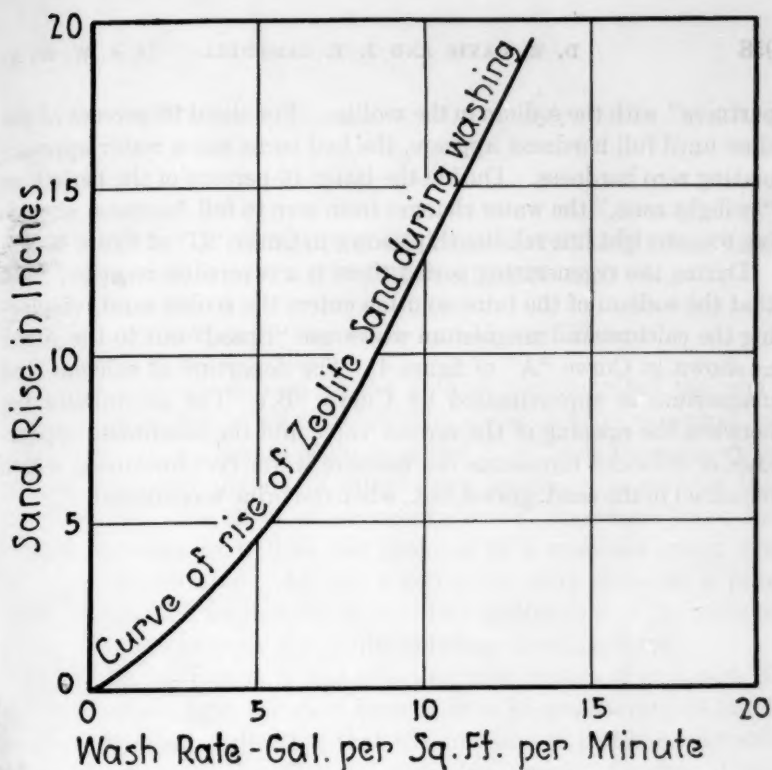


FIG. 3. CURVES FOR "GREEN SAND" RISE DURING BACK-WASHING OPERATION.  
SAND: EFFECTIVE SIZE 0.285 MM. UNIFORMITY COEFFICIENT 1.50

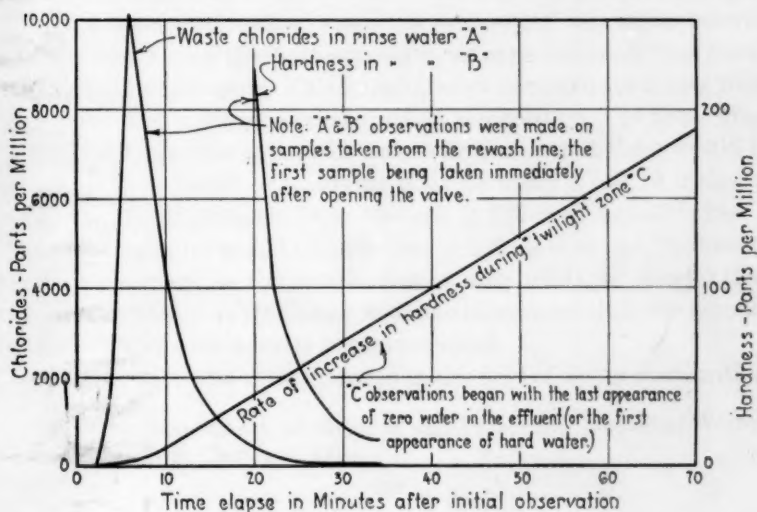
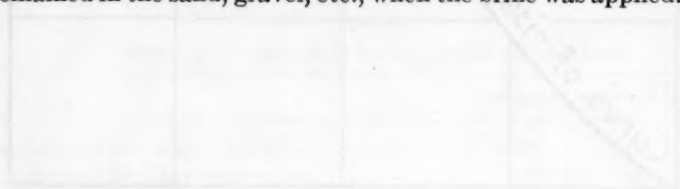


FIG. 4. HARDNESS AND CHLORIDE CHANGES DURING "RINSING" AND "TWILIGHT ZONE" PERIODS

partners" with the sodium in the zeolite. For about 90 percent of the time until full hardness appears, the bed turns out a water approximating zero hardness. During the latter 10 percent of the period, or "twilight zone," the water changes from zero to full hardness according to a straight line relationship shown in Curve "C" of figure 4.

During the regenerating period there is a reversible reaction, in that the sodium of the brine solution enters the zeolite sand, displacing the calcium and magnesium which are "rinsed" out to the sewer, as shown in Curve "A" of figure 4. The departure of calcium and magnesium is approximated by Curve "B." The six minute lag between the opening of the rewash valve and the maximum appearance of chlorides represents the waste of water (yet unbrined) which remained in the sand, gravel, etc., when the brine was applied.



## STERILIZATION OF WATER BY ULTRA-VIOLET LIGHT AS EMITTED BY THE CARBON ARC

BY ROGER G. PERKINS<sup>1</sup> AND HENRY WELCH<sup>1</sup>

In two previous papers (1) the authors demonstrated the rapid bactericidal action of ultra-violet light under definite experimental conditions. The absence of the so-called "lag" period was shown as well as the small amount of interference necessary to prevent this rapid action. The effect of a concentration of organisms below the line of visibility as well as the presence of a resistant group was further demonstrated. All the experiments were done on a pure science basis with no thought of practical applications. The present paper attempts to apply the results of former investigations.

In the earlier papers it was recorded that results of exposure 20 inches from the light for short periods were as satisfactory as much shorter distances, indicating that the increase in distance was still within the limits of the efficiency of the lamp used. Further, it was found that the result was practically the same whether there was air or clear still water between the quartz tubes and the light source.

In our conclusions we stated our belief that the action of the light, when the suspended matter was small in amount, was instantaneous and also that even with short exposures, all save the small "resistant" group would disappear. This group always persisted for a long time, and the ordinary period used in sterilization. If these ideas were correct, and the apparatus was so arranged that there would be an adequate exposure of a moving body of water a full 12 inches in maximum radial distance from the arc, it followed logically that a very brief exposure would be sufficient to kill all save the "resistant" group. Inasmuch as the usual allowed distance is far shorter than this, the possibility of sterilizing with one lamp more than the amount usually treated with a series became evident.

Parkinson (2), who is experienced in the field of water sterilization,

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concludes that baffles are not necessary in apparatus for water sterilization and that the germicidal action takes place almost immediately when the water comes in contact with the rays from the lamp. He states, however, that by the use of baffles a safety factor is obtained which makes sterilization a little more sure.

Ultra-violet light is used for sterilization of water in a few towns in the United States and to a similar extent in Europe. "The advantages of the method are evident, the water itself undergoes no change. The matters in solution and the air, both of which give to water, as a beverage, its pleasing qualities, are retained. An overdose is impossible" (2). The cost under proper conditions is not prohibitive. All towns sterilizing water by ultra-violet light use the mercury arc. Blocher (3) at Berea, Ohio, reports excellent results with their apparatus consisting chiefly of a battery of four mercury arc lamps. He is able to sterilize about 800,000 gallons per day. At Henderson, Kentucky, Smith (4) reports good results with his apparatus which is somewhat different from the one at Berea. A description of his apparatus is given by Ellis and Wells (5) who also note that mercury arc lamps have been found to deteriorate in long use, necessitating frequent estimation of the ultra-violet output. A considerable amount of the ultra-violet radiation is cut off by clouding of the quartz, due probably to decomposition products of the electrodes and to change in the nature of the quartz itself. Since the ultra-violet emission of a carbon arc can be increased to any desired amount within reason by changing the composition of the carbons, and since the total emission of a given mercury arc is limited, it would seem that more efficient sterilization might be effected with the carbon arc.

Since any turbidity interferes with the effect of ultra-violet light, most waters are previously filtered, frequently with the use of a coagulant, so that the average bacterial count of the actual water for treatment is low, probably not over 200 per cc. Unless the raw water was polluted to such an extent as to be unsuitable for use, the water passing the light should not contain *B. coli* in amounts under one per cubic centimeter. Since there is an instantaneous destruction of all but the "resistant" forms, and since these at most are well under 10 percent of the total, one would expect that colon confirmations in the radiated effluent would be rare. In other words, even though it is admitted that unless the period of exposure is far beyond what is practical under commercial conditions, the high percent of *all* organisms destroyed by the ultra-violet, in connection with the

originally small fraction of these represented by *B. coli*, and further in connection with the knowledge that *B. typhosus* if present at all, is in far smaller numbers than *B. coli*, gives a good margin of safety. Study of the actual reports of the Berea plant are confirmatory. The total raw water plate count ranges roughly from 80 to 200 colonies per cc., while the filtered water ranges between 5 and 40. After radiation the total count rarely exceeded 5 per cc. As would be expected from the arguments above, *B. coli* confirmations in the filtered water were 10 percent or less, and very rare in the radiated water.

The usual procedure is to pass the clarified water in a narrow layer past a series of lamps, with the idea that the number will materially increase the safety factor. We believe, however, that the effect of radiation is instantaneous on well over 90 percent of the bacteria, and that the "resistant" forms will in general survive an exposure longer than the total even in a series of four lamps. We have also shown that the effect through 20 inches of clear water is practically identical with that through any less distance, and our study was accordingly made in order to determine whether a single radiation through 12 inches, or about half the distance worked with in the earlier studies, would not give adequate effects. In other words, will a single light source of suitable character, using this radius of 12 inches, remove all but the small "resistant" group, with a commercially practical speed? If this be the case, one lamp will be as efficient as a battery of lamps.

#### APPARATUS

We therefore endeavored to set up in the laboratory an arrangement whereby a continuous flow of clear water could be tested under as nearly as possible plant conditions, so that reasonable conclusions could be drawn from our results.

The apparatus used was very simple (figure 1) composed of a 2-inch galvanized iron pipe (A), so arranged that the supply tank (B) held a constant head, to insure uniformity of flow, and also so that the rays from the carbon arc (C) acted on a 2-inch cylinder of water 12 inches long. Since the speed of flow could be controlled at the outlet by valve (D) to any desired speed or quantity in gallons per second, there was abundant flexibility. Constantly flowing bleeders were established at four points; the first in the pipe at a point before the rays acted on the water (E); the second, at one-third the 12-inch distance available (F); the third, about two inches from the elbow nearest the arc (G); and the fourth, at the outflow (H). A quartz window (I) allowed transmission of the light from the arc. The "C" carbon was used throughout

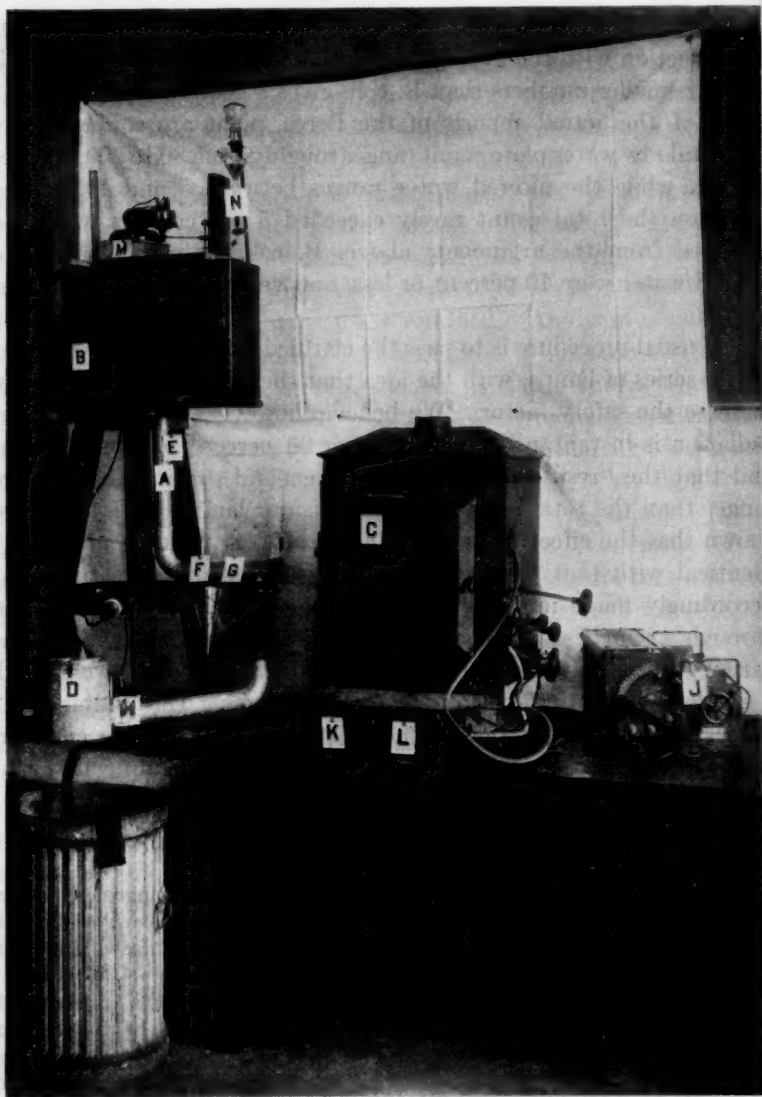


FIG. 1

*A*, galvanized iron pipe; *B*, supply tank; *C*, Power's lamp; *D*, outlet valve; *E*, *F*, *G*, *H*, bleeders; *I*, Quartz window; *J*, variable resistances; *K*, ammeter; *L*, voltmeter; *M*, motor; *N*, constant flow apparatus.

*Note:* Pipe for outflow to sink (through *D*) was originally eight feet long but was shortened for photographic purposes.

this series of experiments. The E.M.F. was kept at 55 volts and the current at 30 amperes by suitable resistances (*J*) interposed in a 110 volt direct current line.

Inasmuch as the flow from the bleeders *E*, *F*, *G* and *H*, was continuous, samples could be taken at any time and compared as seemed desirable. *B. coli* were added continually during experiments by aid of the constant flow arrangement (*N*) consisting of an inverted 250 cc. flask in a funnel. A small 110 volt motor (*M*) to which a paddle wheel was attached kept the water in the supply tank in constant agitation and aided in giving a good distribution of organisms. A float was used to show the height in the supply tank.

#### METHOD

Cultures of *B. coli* grown for 24 hours on standard agar were washed off with 2-5 cc. of saline solution 0.85 percent. This amount was then brought up to 10 cc. and centrifuged at 2500 r.p.m. for fifteen minutes to get rid of the larger clumps. From 0.5 to 5 cc. of the above suspension was added to 300 cc. of saline solution and allowed to enter the water at the supply tank through the constant flow apparatus (*N*). From one to seven drop sof this suspension were added to the water each second, depending on the concentration desired. By regulating the tap and the valve (*D*) at the outlet the level of the water in the supply tank was maintained at about two inches from the top and the outflow of water at about 4000 cc. in ten seconds. Shorter periods were obtained by increasing the outflow.

Before each experiment the apparatus was washed thoroughly by passing tap water through it for fifteen minutes to a half hour, and tests for the presence of *B. coli* were made. The light was started, the tank filled to the proper level and *B. coli* added. Samples were taken at the four bleeders and estimates made of the numbers of *B. coli* present by dilution in lactose broth fermentation tubes. The presence of *B. coli* was determined by acid and gas formation.

#### RESULTS

In general three types of experiments were performed; first, with a comparatively large number of bacteria present; second, with only few bacteria present; and lastly, by placing in the bleeder openings quartz tubes containing a known number of organisms, and determining the numbers present after a period of exposure of four seconds with the water flowing, and without water.

##### *A. Using large numbers of B. coli*

Tables 1, 2 and 3 demonstrate the type of results obtained when over 250,000 *B. coli* per cc. were used. The samples taken from positions *E* and *H* were diluted from 1:2 to 1:262,072 in a regular sequence and 1 cc. added in each case to a lactose broth fermentation tube.

By inspection of table 1 it is seen that in these three cases there were present in the first series approximately 131,000 organisms which an exposure of four seconds has reduced to 8 organisms, whereas in the second and third series the reductions were from 260,000 to 4 and to 64 organisms respectively. It is obvious that the light has a marked effect. This type of experiment has been repeated a number of times with similar results.

TABLE 1

*Showing the reduction of B. coli by ultra-violet light in a one foot column of water when using a high concentration of the organism*

|                             | DILUTION |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |
|-----------------------------|----------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|
|                             | 1        | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| Position H exposed.....     | +        | + | + | + | - | - | - | - | - | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| Position E not exposed..... | +        | + | + | + | + | + | + | + | + | +  | +  | +  | +  | +  | +  | +  | +  | -  |
| Position H.....             | -        | + | - | - | - | - | - | - | - | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| Position E.....             | +        | + | + | + | + | + | + | + | + | +  | +  | +  | +  | +  | +  | +  | +  | +  |
| Position H.....             | +        | - | + | + | - | + | - | - | - | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| Position E.....             | +        | + | + | + | + | + | + | + | + | +  | +  | +  | +  | +  | +  | +  | +  | +  |

Note: + = acid and gas; - = acid, no gas or no acid or gas. First dilution 1:2, next 1:4, etc., to 1:262,072.

#### *B. Using a small number of B. coli*

To approach the conditions found in prefiltered water, the experiments were run with fewer *B. coli* present. In the series shown in table 2, there were under 100 organisms added per cc. Samples were taken from positions *E* and *H* and 0.1, 0.2, 0.5, and 1 cc. added to lactose broth fermentation tubes.

By inspection of table 2 in the A series we find reduction from presence of *B. coli* in 0.1 cc. to absence of *B. coli* in 1 cc.; presence of *B. coli* 0.2 cc. to absence in 1 cc.; and again presence in 0.2 cc. with absence in 1 cc. The series B and C are similar in results. In a group of such experiments this same type of results was obtained. Ten cc. samples taken with these experiments showed presence of *B. coli*. Since under these conditions we have a water simulating a prefiltered one, the results indicate that with the exposure of one foot of water with the proper apparatus, adequate disinfection can be obtained.

## C. Using quartz tubes placed in openings of 2-inch pipe in position F

In order to check the above results, experiments were performed with quartz tubes containing a definite number of organisms placed

TABLE 2

Showing the reduction of *B. coli* by ultra-violet light in a one foot column of water using less than 100 organisms per cc.

|                    | AMOUNT OF SAMPLE ADDED |            |            |            |            |            |            |            |            |            |            |            |
|--------------------|------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                    | 0.1<br>cc.             | 0.2<br>cc. | 0.5<br>cc. | 1.0<br>cc. | 0.1<br>cc. | 0.2<br>cc. | 0.5<br>cc. | 1.0<br>cc. | 0.1<br>cc. | 0.2<br>cc. | 0.5<br>cc. | 1.0<br>cc. |
| A. Position H..... | +                      | +          | +          | +          | -          | +          | +          | +          | -          | +          | +          | +          |
| Position E.....    | -                      | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| B. Position H..... | -                      | +          | +          | +          | +          | +          | +          | +          | -          | +          | +          | +          |
| Position E.....    | -                      | -          | -          | -          | -          | -          | -          | +          | -          | -          | -          | -          |
| C. Position H..... | +                      | +          | +          | +          | +          | +          | +          | +          | -          | +          | +          | +          |
| Position E.....    | -                      | -          | -          | +          | -          | -          | -          | -          | -          | -          | -          | -          |

+ = acid and gas; - = no acid nor gas or acid without gas.

TABLE 3

Showing effect of the light on a *B. coli* suspension in quartz tubes placed in the pipe of the apparatus at position F with and without water flowing  
(Two experiments and control)

|                                    |    | DILUTION |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|------------------------------------|----|----------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|                                    |    | 1        | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Control                            | E  | +        | + | + | + | + | + | + | + | + | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  | -  | -  | -  |
|                                    | E  | +        | + | + | + | + | + | + | + | + | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  | -  | -  | -  | -  |
| Position F,<br>no H <sub>2</sub> O | F, | +        | + | + | + | + | + | + | + | + | +  | +  | +  | +  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
|                                    | F, | +        | + | + | + | + | + | + | + | + | +  | +  | +  | +  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| Position F,<br>water               | F, | +        | + | + | + | + | + | + | + | + | +  | +  | +  | +  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
|                                    | F, | +        | + | + | + | + | + | + | + | + | +  | +  | +  | +  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |

+ = acid and gas, - = acid or no acid or gas.

in the opening of position F, figure 1. The exposure period used was four seconds. The tubes containing the suspensions were placed in the pipe at position F and radiated for four seconds. The water was then turned on and a new quartz tube containing the same type of

suspension was put in and radiated through 12 inches of water. The results of such an experiment are shown in table 3.

Table 3 thus confirms the earlier experiments indicating that penetration through a reasonable amount of clear water is adequate. Since the dilution method shows a very high bacterial count (over 2,000,000 per cc.) and the radiated water only about 10,000, there is a destruction of well over 95 percent.

#### DISCUSSION

These recorded experiments, typical of the much larger series carried out, seem to show that there is an adequate sterilizing effect through a distance of at least 12 inches, with an exposure of four seconds, during which the water is constantly *advancing towards the light source* (a "C" carbon arc). While we believe the four second period more than sufficient, it appears practicable to use this time and still have a commercially useful flow, and the border line "resistant" forms will be removed.

If, however, a column of water with a 12-inch radius can be made to approach a single light source, so that the exposure to radiation begins at a distance of several feet, and if the column continues in a straight line, *after passing the light*, there will be an actual exposure through a distance measured in feet, during which the effect of the light will continue. With such a scheme the flow of the water could be graduated to ensure exposure of every particle for four seconds or more, giving a much greater volume for a single lamp than is now usable for a battery.

It is, of course, appreciated that, inasmuch as the bactericidal action of the rays is practically instantaneous, the total effect may take place at the moment the rays impinge on the organism. Yet our early experience that even in suspensions *visually* clear, but containing large numbers of bacteria in constant motion, there was a delayed reaction, together with the mathematical relations of increasing non-specific opacities, suggests that the movement through this distance may be of value in ensuring actual exposure of each organism to the rays.

The greater flexibility of the carbon arc, due to control of its composition, and to greater range of efficiency with change of electric current, offers distinct possibilities with single powerful lamps. The use of a smooth reflecting surface throughout the irradiated area should increase the efficiency.

## CONCLUSIONS

1. Effective radiation of clear water from a "C" carbon arc begins at a distance at least 12 inches from the light source.

2. A volume of clear water passing a single arc of this type may have a radius of 12 inches at the time of passing, provided the total exposure of each particle, during its passage towards and away from the light source, amounts to four seconds.

3. The residual "resistant" forms will occur in the same proportion with any exposure to ultra-violet light up to a length of time beyond commercial practicability.

4. Our earlier methods, using small laboratory apparatus, are confirmed on a working model.

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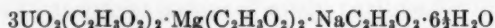
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## THE DIRECT DETERMINATION OF SODIUM IN NATURAL AND TREATED WATER<sup>1</sup>

BY EARLE R. CALEY<sup>1</sup> AND C. W. FOULK<sup>1</sup>

The methods for determining sodium in water have always compared unfavorably with the rapid and convenient procedures available for the determinations of the other constituents. The difference method for sodium as outlined in "Standard Methods of Water Analysis" requires about two days time for its execution and then the results are not especially reliable, due to the numerous operations involved. Shortened procedures have also been devised, but these yield only approximate results. A recent study<sup>2</sup> of the magnesium-uranyl acetate method for the determination of sodium included experiments on the determination of sodium in various synthetic and natural waters and it was found that reliable and accurate results can be obtained in a fraction of the time required by the usual procedure.

The new method consists in precipitating sodium as magnesium uranyl sodium acetate,



with a solution of magnesium uranyl acetate in normal acetic acid. The precipitate is filtered, dried and weighed, or it can be dissolved in water and the yellow solution compared colorimetrically with a standard sodium solution treated in the same way.

### THE PREPARATION OF THE MAGNESIUM URANYL ACETATE REAGENT<sup>3</sup>

The special reagent needed for this direct method is prepared in two parts, the proportions being as follows:

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<sup>2</sup> J. Am. Chem. Soc., 51, 1664-74, (1929).

<sup>3</sup> The authors wish to give credit here to the Journal of the American Chemical Society. The wording in several places in this paper is the same as that in their paper in that journal. See reference 2.

*Solution A*

|                                  |             |
|----------------------------------|-------------|
| Crystallized uranyl acetate..... | 85 grams    |
| Glacial acetic acid.....         | 60 grams    |
| Distilled water.....             | to 1000 cc. |

*Solution B*

|                                     |             |
|-------------------------------------|-------------|
| Crystallized magnesium acetate..... | 500 grams   |
| Glacial acetic acid.....            | 60 grams    |
| Distilled water.....                | to 1000 cc. |

Each solution is separately heated to about 70° until all the salts are dissolved and then the two solutions are mixed at this temperature and allowed to cool to 20°. The large vessel containing the mixed reagent is then placed in water at 20°C., and held at this temperature for an hour or two until the slight excess of salts has crystallized out. The reagent is finally filtered through a dry filter into a dry bottle. The solution thus prepared apparently suffers no alteration upon standing and is permanent for all practical purposes when kept away from direct sunlight. A separate portion of some of the first lot of the reagent kept in a clear glass bottle on the reagent shelf exposed to diffused daylight for eight months showed no change in activity or appearance at the end of this time.

## THE DETERMINATION OF THE PROPER VOLUME OF WATER TO USE

Two marked advantages of the new method, as compared with older procedures, are that:

(1) A much smaller volume of water has to be evaporated preparatory to making a determination.

(2) The correct volume to evaporate can be predicted beforehand.

The procedure for determining this latter point is to add 50 cc. of the clear reagent to 5 cc. of the water, filtered if necessary to remove all suspended matter. The mixture is then vigorously shaken at intervals for five minutes and allowed to stand for several minutes. If no precipitate appears, 100 cc. of water is to be taken for evaporation. If there is a slight turbidity or precipitate, use 50 cc. In the presence of a marked amount of precipitate, use 10 cc. In abnormal cases of very low sodium content (under 5 p.p.m.) it is necessary to take 500 cc. for evaporation. This will be revealed by the non-formation of a precipitate after ten minutes in the course of the regular determination. In the case of boiler waters or other waters in which the sodium content is very high (over 1000 p.p.m.) a 5 cc. sample should be taken, no evaporation being required in this latter case. In taking such small samples accurate pipettes should be used.

## THE GRAVIMETRIC DETERMINATION

Both gravimetric and colorimetric procedures have been worked out in this new method. It is advisable to use the former to obtain very accurate results and in the case of waters of high sodium content it invariably should be used.

*Procedure*

The sample of water for evaporation is made distinctly acid with hydrochloric acid and evaporated to dryness on a water bath. The residue is treated with successive 3 to 5 cc. portions of hot water delivered from a wash bottle, and is transferred during this operation to a small filter and funnel placed over a 250 cc. Pyrex flask. The extraction of the residue with small portions of hot water is continued until the total volume of the filtrate is 20 to 25 cc. This is then rapidly evaporated to a volume of 5 cc. by heating the flask over a bare flame. If a white precipitate of calcium sulphate separates during this latter operation add 0.3 to 0.5 gram of solid ammonium chloride and shake until the precipitate dissolves. One hundred cubic centimeters of the magnesium-uranyl acetate reagent is then added and the two solutions are rapidly mixed. The flask is next partly immersed in a water bath maintained at 20°C. and the solution vigorously stirred for 30 to 40 minutes. The precipitate is then immediately filtered into a weighed Gooch crucible and washed with successive 5 cc. portions of 95 percent alcohol. The crucible and precipitate are finally dried in an air oven at 105 to 110°C. for 30 minutes and weighed. The weight of the precipitate in grams, plus 1 mgm. for each 5 cc. of alcohol used in washing, times the factor 0.0153 gives the sodium content of the sample taken for evaporation.

The following formula can conveniently be used for calculating the p.p.m. of sodium in the original water.

$$\text{Na in p.p.m.} = [(W + C) \times 0.0153] \frac{1000}{V}$$

*W* = observed weight of the precipitate in mgm.

*C* = washing correction of 1 mgm. for each 5 cc. of alcohol used in washing.

*V* = volume of water sample in cubic centimeters.

*Notes*

1. It is not necessary to remove suspended matter from the sample to be evaporated. By acidifying the solution the sample may be evaporated in porcelain with practically no effect from the material of the vessel as far as the sodium content of the water is concerned. The addition of hydrochloric acid has been found also to lead to a more soluble residue. If the organic matter is very high the residue should be charred before proceeding with the determination.

2. It is sometimes necessary to filter the reagent before use in case the original filtration was not entirely effective.

3. A thermostatic control is wholly unnecessary for regulating the temperature at 20°C., since a variation of a degree either way does no harm. For the short course of a determination it is only required to fill a large trough or vessel with water brought to 20°C. and pay no further attention to temperature control. The stirring or shaking should be vigorous since gentle agitation invariably leads to incomplete precipitation.

4. During filtration the solution should be continually stirred to prevent the crystalline precipitate from adhering to the sides of the flask. The alcohol is preferably delivered from a graduated wash bottle having a fine tip. The first portions should be used to remove the adhering precipitate from the sides of the flask with the aid of a policeman. The end of the washing process is indicated by the liquid going through colorless. Ordinarily 20 to 30 cc. of alcohol are required. A phenomenon that attends the washing of these precipitates should be mentioned because of its deceptive appearance. There frequently appears in the filtrate a precipitate closely resembling that of the triple acetate which makes it appear as though the precipitate were running through the filter. This precipitation is due simply to salts thrown down from the concentrated solution by the alcohol.

5. The drying temperature should not be allowed to rise above 110°C. since the precipitate begins to decompose at slightly higher temperatures.

6. By the reason of the small factor and the slight uncertainty involved in the washing correction there is no advantage in weighing closer than the third decimal place. The use of a washing correction may be eliminated by washing with 95 percent alcohol saturated with the triple acetate.

#### THE COLORIMETRIC DETERMINATION

For waters of low and medium sodium content a colorimetric modification of the above procedure may advantageously be used. The colorimetric method will not give accurate results on waters of high sodium content (above 200 p.p.m.) but for the average water it gives values that differ little from those obtained gravimetrically, and with a considerable saving of time. It is especially applicable for determining the sodium content of a series of waters.

#### *Procedure*

The sample of water is evaporated and the precipitation is made in exactly the same manner as in the gravimetric method outlined above except that the precipitate is collected upon an unweighed Gooch crucible. Then, instead of drying and weighing the precipitate, air is drawn through the Gooch crucible on the filtering flask for 3 to 5 minutes to remove most of the adhering alcohol, the precipitate is dissolved in water and the resulting yellow solution is compared colorimetrically with a suitable standard. The most convenient and rapid procedure is to remove the crucible and its holder from the filtering flask and to place it over a graduated colorimeter tube. The precipitate is dissolved out and the solution allowed to run through into the tube by pouring 2 to 3 cc. portions of warm water (60° to 70°C.) through the crucible. After the

precipitate has dissolved, the colored solution is cooled in water at room temperature and made up to some definite volume, between 15 and 25 cc. depending upon the volume of water required to dissolve out the precipitate. The depth of color of the sample is then compared with the depth of color of a standard treated in the same way.

### Notes

1. It is necessary to remove practically all the adhering alcohol in the manner described since the presence of alcohol in the subsequent solution of the precipitate frequently causes a turbidity, due to precipitated salts.

2. Care must be taken to use only small portions of water in dissolving out the precipitate in order not to exceed the small total volume needed for comparison.

3. Satisfactory results are obtained only by using an accurate colorimeter such as the Duboseq type. The use of ordinary color tubes is not recommended.

4. The sharpest results in matching the colors are obtained if the solutions exhibit a strong straw color when viewed in the colorimeter. At least five readings should be taken on each pair of color tubes and the results averaged for the final value in order to minimize the error inherent in judging the equality of the colors.

5. A standard of approximately the same concentration as that of the sample should be used. This can be prepared by precipitating the sodium from measured volumes of a pure sodium chloride solution. A convenient strength to employ is 2.542 grams of sodium chloride per liter. One cubic centimeter of this solution is equivalent to 1 mgm. of sodium. Permanent color standards prepared in this manner may be advantageously employed in this procedure where numerous determinations are to be made.

6. A peculiar advantage of the colorimetric method is that the presence of suspended matter in the solution before precipitation will not affect the final results.

### A TEST OF THE NEW METHOD ON SYNTHETIC WATERS OF KNOWN SODIUM CONTENT

For the purpose of determining the accuracy of results obtainable by means of the above procedures a series of synthetic waters of known sodium content were prepared. These waters also contained other inorganic constituents in proportions typical of rather highly mineralized, hard waters. The waters were prepared from standard solutions of inorganic salts, which had been properly purified, especially in regard to freedom from sodium. In some cases the content of alkalis other than sodium was especially emphasized in order to test the worth of the method. These waters were preserved in paraffined glass-stoppered bottles in order to insure an unchanging composition. The composition of several of these synthetic waters in parts per million is given below.

| No. 1                 |     | No. 3                 |     | No. 4                 |      |
|-----------------------|-----|-----------------------|-----|-----------------------|------|
| Ca.....               | 100 | Ca.....               | 100 | Ca.....               | 400  |
| Mg.....               | 50  | Mg.....               | 50  | Mg.....               | 200  |
| Na.....               | 5   | Na.....               | 100 | Na.....               | 500  |
| K.....                | 5   | K.....                | 100 | K.....                | 200  |
| Fe.....               | 1   | Fe.....               | 1   | Li.....               | 5    |
| NH <sub>4</sub> ..... | 1   | NH <sub>4</sub> ..... | 1   | Fe.....               | 10   |
| Cl.....               | 210 | Cl.....               | 400 | NH <sub>4</sub> ..... | 10   |
| SO <sub>4</sub> ..... | 52  | SO <sub>4</sub> ..... | 52  | Cl.....               | 1505 |
|                       |     |                       |     | SO <sub>4</sub> ..... | 220  |

The results of analyses made upon the synthetic waters by the magnesium-uranyl acetate method are shown in table 1.

#### THE DETERMINATION OF SODIUM IN SEVERAL NATURAL WATERS BY THE NEW METHOD AND BY THE STANDARD METHOD

Several typical natural waters were obtained and their sodium content determined by the two methods. The results appear in table 2.

There is good reason to believe that the new method gives values for sodium that are nearer the truth than those obtained by the standard method. The great advantage of the new method, however, lies in the economy of time in making the determinations since, with evaporations, the standard method requires about two days, whereas results are obtained by the new method in a few hours, including the time consumed in the original evaporation of the water.

#### A RAPID TECHNICAL METHOD FOR THE ESTIMATION OF THE SODIUM CONTENT OF WATER

The preceding method was found to give exact results for the sodium in water. The necessity for mechanical shaking or stirring, however, was thought to be a drawback which might prevent its use in laboratories not equipt with such appliances. Experiments were made therefore with the view of eliminating mechanical shaking or stirring, and at the same time provide a rapid method that would give results sufficiently accurate for technical purposes. The following procedure is the result of these experiments. Aside from eliminating mechanical stirring, it differs from the exact method in a few minor points

#### *Procedure*

Determine the quantity of water to be evaporated by a qualitative test in the same manner as with the exact method. Acidify the water sample with

TABLE 1

*The determination of sodium in several synthetic waters of accurately known composition*

| SODIUM CONTENT<br>OF WATER | VOLUME EVAPORATED | SODIUM FOUND<br>GRAVIMETRICALLY | SODIUM FOUND<br>COLORIMETRICALLY |
|----------------------------|-------------------|---------------------------------|----------------------------------|
| <i>p.p.m.</i>              | <i>cc.</i>        | <i>p.p.m.</i>                   | <i>p.p.m.</i>                    |
| 5                          | 100               | 4                               | 4                                |
|                            |                   | 4                               | 4                                |
| 25                         | 100               | 25                              | 25                               |
|                            |                   | 25                              | 25                               |
| 50                         | 100               | 48                              | 47                               |
|                            |                   | 49                              | 48                               |
|                            |                   |                                 | 50                               |
|                            |                   |                                 | 51                               |
| 100                        | 50                | 102                             | 102                              |
|                            |                   | 102                             | 103                              |
|                            |                   |                                 | 98                               |
|                            |                   |                                 | 96                               |
| 500                        | 10                | 505                             |                                  |
|                            |                   | 500                             |                                  |
|                            |                   | 499                             |                                  |

TABLE 2

*Determination of sodium in several natural waters by the new method as compared with results obtained by the standard procedure*

| WATER<br>NUMBER | VOLUME<br>NEEDED FOR<br>NEW METHOD | VOLUME<br>NEEDED FOR<br>STANDARD<br>METHOD | SODIUM<br>CONTENT BY<br>STANDARD<br>METHOD | SODIUM FOUND<br>BY NEW<br>GRAVIMETRIC<br>PROCEDURE | SODIUM FOUND<br>BY NEW<br>COLORIMETRIC<br>PROCEDURE |
|-----------------|------------------------------------|--|--|--|---|
|                 | <i>cc.</i>                         | <i>cc.</i>                                 | <i>p.p.m.</i>                              | <i>p.p.m.</i>                                      | <i>p.p.m.</i>                                       |
| 1               | 100                                | 750  | 34   | 35   | 36  |
|                 |                                    |  | 38   | 35   | 36  |
| 2               | 500                                | 1,000                                      | 2.7  | 1.7  | 1.9   |
|                 |                                    |  | 3.1  | 1.8  | 2.1   |
| 3               | 10                                 | 200  | 370  | 372  |   |
|                 |                                    |  | 365  | 370  |   |
|                 |                                    |  |  | 363  |   |
|                 |                                    |  |  | 366  |   |

Water no. 1—Columbus tap water collected March 21, 1928.

Water no. 2—Water taken from surface well near Columbus, Ohio.

Water no. 3—Abnormal soft water containing sodium bicarbonate in solution, collected from a well at Worthington, Ohio.

hydrochloric acid and evaporate to dryness, first over a bare flame and then, toward the end of the operation, on a water bath. Dissolve the residue in small portions of hot water, filtering at the same time into a 250 cc. Pyrex flask. Rapidly evaporate the filtrate over a bare flame until a volume of 5 cc. is reached. If a white precipitate due to calcium sulphate forms during this latter evaporation add 0.3 to 0.5 gram of solid ammonium chloride and shake gently until the precipitate dissolves. Add 100 cc. of magnesium-uranyl acetate reagent to the liquid in the flask, stopper the latter and shake thoroughly. Then place the flask in a large pan of water at 20°C. and shake

TABLE 3

*Showing results obtained on synthetic waters by the rapid technical method for the estimation of sodium in water*

| SODIUM CONTENT OF<br>SYNTHETIC WATER | VOLUME OF WATER<br>TAKEN FOR THE<br>DETERMINATION | TOTAL TIME INCLUDING<br>EVAPORATION | SODIUM FOUND |
|--------------------------------------|---|-------------------------------------|--------------|
| p.p.m.                               | cc.   | hours                               | p.p.m.       |
| 5                                    | 100   | 2                                   | 5            |
|                                      |   |                                     | 4            |
|                                      |   |                                     | 6            |
|                                      |   |                                     | 5            |
| 50                                   | 100   | 2                                   | 47           |
|                                      |   |                                     | 46           |
|                                      |   |                                     | 52           |
|                                      |   |                                     | 49           |
| 200                                  | 10  | 1½                                  | 200          |
|                                      |   |                                     | 195          |
|                                      |   |                                     | 195          |
|                                      |   |                                     | 200          |
| 500                                  | 10  | 1½                                  | 470          |
|                                      |   |                                     | 480          |
|                                      |   |                                     | 510          |
|                                      |   |                                     | 510          |

thoroughly by hand at frequent intervals during a period of thirty minutes. Filter the precipitate through a dried unweighed Gooch crucible and wash with 95 percent alcohol in the usual way. Place the crucible with its holder over a graduated colorimeter tube and dissolve the precipitate out with 2 to 3 cc. portions of warm water. Cool the filtrate in the tube rapidly by immersing in the pan of water kept at 20°C. and make up to a final volume of 15 or 20 cc. Compare the color of the sample with that of a standard treated in the same way, using a colorimeter. Table 3 shows typical results obtained with the above method.



## AN ODE TO A DROP OF WATER\*

Do you ever stop to think about  
A little drop of water,  
And its journey from the sky down to the tap?  
Do you think about its travels—  
If you don't you really ought'er—  
For that little drop of water has no snap!

From a home up in a cloudlet,  
It is vig'rously ejected,  
And descends precipitately down below.  
After landing on a hillside—  
There's no wonder its dejected,  
As it turns about to find a place to go.

Turbidity and Coli meet  
This little drop of water  
As it journeys down the hillside running free.  
And it cannot guess the treatment—  
And it knows naught of the slaughter,  
That awaits it on its journey to the Sea!

Soon it finds itself impounded,  
In a reservoir surrounded,  
And our droplet gets an inkling of its fate,—  
As it nearly comes a cropper  
When subjected to some Copper  
As it travels with some Algae toward the Gate!

There perhaps it is aerated,  
And of course pre-chlorinated—  
Now a days, ammoniated—Such a Life!  
And with Lime that's been hydrated—  
It is then coagulated,  
And its insides desiccated—by the Strife!

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\* Written by Wm. J. Orchard on the *Spirit of St. Louis*, June 2, 1930, between the Club Car and the Observation Platform—betwixt and between conversations with J. W. Boyer, P. N. Engel and J. W. Armstrong. Presented before the Water Purification Dinner, the St. Louis Convention, June 3, 1930.

When some devil of a Chemist—  
Adds some Alum for good measure,  
Can we wonder if our droplet feels the pain?  
As it has its pH taken,  
We are sure it feels forsaken  
And when passing through the filter feels the strain!

Even then it is not finished—  
Nor the punishment diminished,  
How on earth can all those Chemists be so mean?  
For this little drop of water,  
Is deprived of Son—or Daughter,  
As its Sterilized—with plenty of Chlorine!

Then it passes through the clear well,  
Do you wonder it don't hear well,  
As it's pumped and pushed and forced right to the sink?  
And its sobs and sighs are fewer,  
As it flows down to the sewer,  
That's a long and trying journey—don't you think?

Do you ever stop to think about  
A little drop of water,  
And its journey from the sky down to the tap?  
Do you think about its travels—  
If you don't you really ought'er,  
For that little drop of water has no snap!

## SOCIETY AFFAIRS

### THE SOUTHEASTERN SECTION

The Southeastern Section held its annual meeting April 15, 16 and 17, 1930 at Savannah, Georgia. The attendance was over one hundred and fifty. The papers on the program covered many phases of water supply and stimulated a great deal of discussion.

The convention banquet furnished an evening of unusually pleasant entertainment. The barbecue was further proof that the local entertainment committee spared nothing in adding to the success of the meeting.

The officers of the Section are: H. F. Wiedeman, Atlanta, Ga., Chairman; G. H. White, Columbia, S. C., Vice Chairman; Herve Charest, Mobile, Ala., Local Director; R. E. Findlay, Macon, Ga., Local Director; W. W. Pointer, Clarksdale, Miss., Local Director; H. W. Schumpert, Newberry, S. C., Local Director; J. E. Gibson, Charleston, S. C., Representative to the Association Board of Directors; W. H. Weir, Atlanta, Ga., Secretary-Treasurer.

The report of the Membership Committee showed a gain of over twenty members since January 1, 1930.

W. H. WEIR,  
*Secretary-Treasurer.*

### THE FLORIDA SECTION

The fourth annual meeting of the Florida Section was held in Gainesville, Florida, on April 10 and 11, 1930. It was preceded by the first Short Course in Water and Sewage Treatment offered by the General Extension Division of the University of Florida, in conjunction with the Florida Section, American Water Works Association, and the Florida State Board of Health, on April 8 and 9. Enrollment for the Short Course considerably exceeded the expectations of those in charge, sixty-nine having registered during the two days in which it was given. Conforming with the request of the Association the Short Course will be made an annual affair, and the time will be extended to four or five days, thus permitting a more thorough treatment of the subjects discussed.

The registration for the fourth annual meeting was the largest in the history of the Section, some one hundred and twenty-five being in attendance. During the two day session nineteen papers were presented and discussed. Among them were:

"Treatment of Boiler Waters," Edward Bartow, University of Iowa, Iowa City, Iowa.

"Hardness in Water Supplies in the United States," W. D. Collins, Chief Chemist, Division of Quality of Water, U. S. Geological Survey, Washington, D. C.

"Federal and State Co-operation on Investigation of Water Resources," N. C. Grover, Chief Hydraulic Engineer, U. S. Geological Survey, Washington, D. C.

"Certifying Water Supplies for Interstate Carrier Use," R. E. Tarbett, Sanitary Engineer, U. S. Public Health Service, Washington, D. C.

"Chlorine—Its Use in Water Treatment," Linn H. Enslow, Engineer, Chlorine Institute, New York City.

"A Practical Program for Elimination and Control of Cross Connections," C. W. Mowry, Boston, Massachusetts, Manager, Inspection Division, Associated Factory Mutual Fire Insurance Company.

West Palm Beach, Florida, was selected as the meeting place for 1931. Officers elected were as follows: A. P. Black, Professor of Chemistry, University of Florida, Gainesville, Florida, Chairman, F. W. Lane, St. Petersburg, Florida, Vice-Chairman, E. L. Filby, State Board of Health, Jacksonville, Florida, Secretary-Treasurer, (reelected). Director for 1932, J. R. Hoy, Jacksonville, Florida. Directors for 1933, J. R. Tanner, West Palm Beach, Florida, and T. W. Grant, Tampa, Florida. Representative to the Board of Directors, A. W. W. A., A. P. Michaels, Orlando, Florida.

E. L. FILBY,

*Secretary-Treasurer.*

#### THE ILLINOIS SECTION

The twenty-second annual convention of the Illinois Section was held at the Stevens Hotel, Chicago, on April 23 and 24, 1930. The official registration list shows that 133 members and guests were present at the meeting.

The first meeting was called to order at 1:40 p.m. on April 23. Chairman Knowles appointed Messrs. Habermeyer, Gelston, and Ringness on a Committee of Tellers to canvass the nominating ballot,

requesting that their report be given at the conclusion of the afternoon program.

Announcements were made by the chairman concerning the National Membership Drive and urging that the members participate and coöperate in order that the Illinois Section might reach its quota before the St. Louis Convention.

The report of the tellers showed that the following nominees had been selected as the result of the canvass of the ballots which had been sent out to the members thirty days before the date of the meeting: Chairman, Enger, Knowles, Tonney; Vice Chairman, Burdick, Baylis, Crozier; Treasurer, Keeler; Trustee, Tonney, Knowles, Hanley.

A proposal to amend Article 5, section 2 of the by-laws of the Illinois Section was offered from the floor. After discussion and consideration of two proposed drafts which were presented, the following was adopted:

Article 5, Section 2 of the constitution and by-laws of the Illinois Section shall be amended to read as follows:

At least sixty days before the annual meeting the chairman shall appoint a Nominating Committee of three members. The Nominating Committee will designate the nominees for Chairman, Vice Chairman, Treasurer, and one Trustee, and notify the Secretary of its action at least forty-five days prior to the date of the annual meeting. The Secretary shall, at least thirty days before the annual meeting mail to each member a ballot on which shall be printed the nominees designated by the Nominating Committee. There shall also be provided on the ballot a space in which any member may write the name of his choice for any or all offices. Ballots shall be canvassed at the annual meeting and the member receiving the largest number of votes for the various offices shall be declared elected. The Secretary shall be appointed by the Executive Committee for a term of three years.

The program presented at the Wednesday meeting was as follows:

Production and Distribution of Water for Railway Use, by J. P. Hanley, Illinois Central System. Discussion by J. H. Davidson, E. M. Grime and J. R. Hickox.

The Treatment of Water for Railway Boiler Use, by C. H. Koyl, Chicago, Milwaukee, St. Paul and Pacific Railroad. Discussion by R. C. Bardwell and P. W. Evans.

Sanitary Control of Railway Water Supply by R. E. Coughlan, Chicago and Northwestern Railway System. Discussion by D. A. Steel and L. I. Birdsall.

Effect of Improper Coagulation on Boiling Characteristics of Water (Illustrated by Motion Pictures), by G. J. Fink, National Aluminate Corporation.

The Sheboygan Water Works Filtration Plant, by Charles B. Burdick, of Alvord, Burdick and Howson.

The annual dinner, with 148 members and guests present, was held in the South Ball Room of the Stevens Hotel at 7 p.m. on Wednesday, April 23, 1930. Mr. C. R. Knowles acted as toastmaster.

The principal address of the evening was given by Mr. Loran D. Gayton, City Engineer of Chicago, who under the subject of "The Floater" paid a glowing tribute to those unknowns who drive the rivets and remove the muck in the accomplishment of great engineering projects.

Mr. George Fenkell, president-elect of the American Water Works Association, gave a brief résumé of the work in which the Association might profitably engage.

Mr. Howson explained the requirement for the election of the Trustee to the national association. Mr. C. R. Knowles was unanimously elected to this position.

The Section voted to send a telegram to Mr. H. M. Ely of Danville, congratulating him on his rapid recovery to health.

The ballots were distributed for election of officers for the ensuing year and the report of the tellers indicated that the following men had received the greatest number of votes for the respective offices and they were declared elected: Chairman, M. L. Enger; Vice Chairman, C. B. Burdick; Treasurer, H. E. Keeler; Trustee, C. R. Knowles.

The meeting Thursday morning was called to order by Chairman Knowles at 9.15 o'clock. Announcement of the result of the election of officers for the ensuing year was made. The following program was then presented:

Proposed Changes in Standard Methods for the Examination of Water and Sewage, by A. M. Buswell.

Sanitary Standards for Collecting Reservoirs (Illustrated), by C. W. Klassen. Discussed by J. R. Baylis.

Direct Plating of Coli-Aerogenes Organisms—Its Possibilities and Promise, by Fred O. Tonney. Discussed by Baylis and Mohlman.

Gas Production and pH Determinations of Coli-Aerogenes Cultures on Sugar Broths, by C. C. Ruchhoft. Discussed by Tonney and Noble.

Chicago's Water Supply (Illustrated by Motion Pictures), by Justus B. Eddy.

Pools and the Waterworks Man, by Arthur M. Crane. Discussed by Luscomb.

Prof. M. L. Enger, Chairman-elect, was introduced. Professor Enger offered a resolution that the appreciation of the Association be expressed to the International Filter Company and the Illinois Central Railway Company for the assistance furnished for registration and clerical work for the meeting and that the secretary send a letter to these companies expressing the thanks of the Illinois Section. The motion was carried.

Meeting was adjourned by 12.30 p.m.

About 30 members and guests enjoyed the inspection trip to the William Hale Thompson Pumping Station and Experimental Filtration Plant on Thursday afternoon, April 24, 1930.

J. J. DOLAND,  
*Secretary.*

#### THE PACIFIC NORTHWEST SECTION

The third annual meeting of the Pacific Northwest Section was held at Portland, Oregon, April 24-26, 1930. This meeting was attended by 149 members and guests.

At the business meeting, held on April 24, the following officers and director were elected: Chairman, Alex Lindsay, Superintendent Water Department, Spokane, Washington; Vice Chairman, Carl A. McClain, General Superintendent, Secretary, Eugene Water Board, Eugene, Oregon; Secretary-Treasurer, R. F. McLean, Superintendent Water Department, Walla Walla, Washington; Director, R. H. Corey, Division Engineer, Public Works Engineering Corporation, Salem, Oregon; Director (Hold Over), Fred J. Sharkey, Superintendent Water Department, Wenatchee, Washington.

At this meeting, also, W. A. Kunigk, Superintendent Water Division, Tacoma, Washington, was elected National Director to hold office until 1932.

At this time the Secretary reported that the total membership of the Section, including ten which had not yet been acted upon by the National Board of Directors, consisted of 58 active members, 4 associate members and 6 corporate members; representing a gain since the last annual meeting, which was held in Spokane, Washington, May 17-18, 1929, of twenty members.

The Secretary also reported that since the beginning of the national campaign for the increase in membership, that this Section had sent in twelve applications, or 80 percent of its quota, which had been fixed by the Membership Campaign Committee.

The Secretary also reported that notices of the third annual meeting had been sent to over 600 persons, at least 450 of whom were eligible for membership in this Section.

The financial report for the Section was read, showing a balance on hand, not including receipts and expenses in connection with this meeting, of \$92.68.

At this meeting an address was given by Mr. Jack J. Hinman, Jr., the National President, on "Treating a Tropical Water Supply."

At the dinner meeting, held on Friday, April 25, an address was given by Mr. Hinman on the aims and purposes of the American Water Works Association, which was followed by the presentation of the golf prizes and short talks by Ben. S. Morrow, retiring Chairman, and Ernest C. Willard, retiring Secretary-Treasurer.

The receipts from registration fees were \$622.50, and the expenses incident to this meeting were \$562.95.

ERNEST C. WILLARD,  
*Secretary.*

#### THE MONTANA SECTION

The fifth annual meeting of the Montana Section was held in Missoula, April 17, 18 and 19, 1930. This meeting was characterized by more enthusiasm and interest than evinced at any previous gathering of the Section. Those instrumental in securing and fostering this organization were unanimous in the opinion that the Section is now on a sure and permanent footing and will go forward.

President Jack Hinman with his engaging personality and enthusiasm was the big drawing feature of the meeting. He made several speeches in which he showed his comprehensive grasp of the problems confronting the water works operator and administrator. On Wednesday noon, preceding the meeting, Mr. Hinman gave a ten minute talk over the radio at Great Falls (station KFBB) on the subject of "The Water Supplies of Cities." The range of this station is practically all of Montana and parts of the adjacent territory.

Emil Sandquist, City Engineer of Havre, President of the Montana Section, presided. Mr. Cortese, Superintendent of the City water Department, Livingston, Vice-President, conducted the round table discussions and was otherwise active in the business at hand.

The round table discussions of the first day were a prominent feature of the meeting. Our water works men have much the same problems as confront the men in such work the country over and

entered in the discussions with tales of experiences and methods of solving troubles that produced a volume of invaluable information. This was all taken by a court reporter and will be transcribed in detail as soon as possible.

The papers called for by the program were all given, often illustrated by charts and photographs which increased their interest.

Trips were taken by the delegates to Bonner to see one of the large saw mills in the district in operation, and to the intake works of the local water supply system. At the latter place lunch was served by the Montana Power Company, owners and operators of the water utility in Missoula.

Mr. Christensen, Manager of the Missoula Branch of the Montana Power Company, was a genial host. He has been a member of the A. W. W. A. since 1929. Mr. Thane, Superintendent of the Water Department of this company, took the brunt of the local arrangements and did his work so thoughtfully that never a hitch occurred in the proceedings. All past presidents of the Montana Section were on hand.

The registration list shows 58 names. Other local men visited the meetings from time to time.

The new officers elected for the ensuing year are: J. R. Cortese, Superintendent, Water Department, Livingston, President; H. M. Johnson, Superintendent Water Department, A. C. M. Company, Anaconda, Vice-President; Eugene Carroll, Vice-President, and General Manager, Butte Water Company, Butte, Director of the A. W. W. A.; H. B. Foote, Sanitary Engineer, State Board of Health, Helena, Secretary-Treasurer.

Anaconda was selected as the meeting place in 1931.

H. B. FOOTE,  
*Secretary-Treasurer.*

## ABSTRACTS OF WATER WORKS LITERATURE<sup>1</sup>

FRANK HANNAN

**Key:** American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

**Dimethyl- $\alpha$ -naphthylamine for Determination of Nitrite Ion.** FREDERICK G. GERMUTH. *Ind. Eng. Chem., Anal. Ed.*, 1: 28-9, 1929. From *Chem. Abst.*, 23: 1079, March 10, 1929. Dimethyl- $\alpha$ -naphthylamine produces a more stable and more distinct coloration than  $\alpha$ -naphthylamine in solutions containing small quantity of nitrite. Solution containing 5.25 grams of the amine dissolved in 1 liter of methyl alcohol which has been made 4 normal in acetic acid is recommended as reagent in water analysis.—*R. E. Thompson.*

**The Estimation of Borate in Natural Waters.** MARGARET D. FOSTER. *Ind. Eng. Chem., Anal. Ed.*, 1: 29-31, 1929. From *Chem. Abst.*, 23: 1080, March 10, 1929. Add 1 cc. 0.46 N hydrochloric acid and 1 cc. 1 percent turmeric solution to 10 cc. of sample in white dish, and evaporate to dryness slowly on steam bath. If residue is pink or rose, boric acid is present and may be determined by comparison with suitable standards.—*R. E. Thompson.*

**Fusible Metal Safety Plugs in Chlorine Containers.** Compressed Gas Manufacturers Assoc. Bull., Tech. Series 1929, 359-60. From *Chem. Abst.*, 23: 1090, March 10, 1929. Report of researches by Niagara Alkali Co. on fusible metal plugs for 150-pound cylinders. Failure to function properly is due to one of two causes; (1) corrosion (most important), and (2) segregation; the packing of primary bismuth crystals across plug. Formula of the quaternary eutectic is: cadmium 10.10, tin 13.13, lead 27.27 and bismuth 49.50 percent. This alloy is now employed and plugs are chilled immediately after pouring.—*R. E. Thompson.*

**Remarks on the Work of W. Blumenberg "On the Indole Titer According to Gersbach in Water Analysis."** M. NEISSER. *Centr. Bakt. Parasitenk.*, I Abt., 109: 346-50, 1928; cf. *C.A.*, 22: 3473. From *Chem. Abst.*, 23: 1150, March 10, 1929. Method is useful in water analysis and pure bacteriology.—*R. E. Thompson.*

**Electroösmotic Water Purification.** II. A. H. W. ATEN. *Chem. Weekblad.*, 25: 646-8, 1928; cf. *C.A.*, 22: 2421. From *Chem. Abst.*, 23: 1192, March 10, 1929. Calculation shows that purification can also be obtained with dia-

<sup>1</sup> Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

phragms in which ions have same mobility as in water, providing anolyte and catholyte are of definite acidity and alkalinity respectively.—*R. E. Thompson.*

**The Problem of Biochemical Decomposition of Phenol in Natural Water.** H. BACH. *Gesundh. Ing.*, 51: 773-4, 1928. From *Chem. Abst.*, 23: 1192, March 10, 1929. Experiments were carried out in glass vat of 210 liters capacity. Bottom was lined with sand and goldfish were placed in the water. When 10 p.p.m. of phenol was added, only trace remained after 4 days. Second addition of 10 p.p.m. gave similar results. Phenol in amounts up to 25 p.p.m. was rapidly destroyed. Further additions resulted in retarded decomposition. Additions of 10 p.p.m. seemed to have no harmful effect on goldfish.—*R. E. Thompson.*

**Removing Gas from Water.** M. EULE. *Gesundh. Ing.*, 51: 801-6, 1928. From *Chem. Abst.*, 23: 1192, March 10, 1929. Carbon dioxide is ordinarily removed by means of alkalies. Oxygen can be removed by chemical or mechanical means. Illustrations of apparatus used for removing dissolved gas from water given.—*R. E. Thompson.*

**Town Water Supply in India.** J. W. MADELEY. *J. Roy. Soc. Arts*, 77: 24-47, 1929. From *Chem. Abst.*, 23: 1193, March 10, 1929. It is very difficult to obtain sufficient water to meet needs of Indian towns owing to lack of funds and scarcity of good water. Data given on water supply of Madras.—*R. E. Thompson.*

**The Future of Berlin's Water Supply.** A. FEILITZSCH. *Gesundh. Ing.*, 51: 785-7, 1928. From *Chem. Abst.*, 23: 1193, March 10, 1929. Description of Berlin water supply, consisting of water derived mainly from surface sources which is filtered and chlorinated.—*R. E. Thompson.*

**The Use of Artesian Water for Water Supply of Mitau.** G. THIEM. *Gesundh. Ing.*, 52: 7-10, 1929. From *Chem. Abst.*, 23: 1193, March 10, 1929. Description of supply of Mitau, a city of 40,000 inhabitants in Lettland.—*R. E. Thompson.*

**Comparing Detergents and Wetting Agents by Their Effects on the Hardness Test for Water.** H. PERNDANNER and J. HACKL. *Melliand Textilber.*, 9: 913-5, 1928. From *Chem. Abst.*, 23: 1194, March 10, 1929. Presence of detergents other than soaps and of wetting agents cause change in apparent hardness of water as estimated by Clark test. Using standard water of 12° (German) hardness, and solutions containing 0.1 to 0.2 gram per 100 cc. of various products, apparent hardnesses of from 6.9° to 11.1° were obtained.—*R. E. Thompson.*

**The Dissolving of Lead from Water Pipes.** A. FARINE. *Tech. Ind. Schweiz. Chem.-Ztg.*, 1927, No. 3-4, 29-32. From *Chem. Abst.*, 23: 1195, March 10, 1929. Theoretical deductions check with laboratory data in demonstrating that free carbon dioxide in water greatly accelerates the lead-dissolving action of that water. On other hand, bicarbonates greatly reduce the action. Sample con-

taining only free carbon dioxide dissolved 10.5 milligrams lead per liter; but when carbon dioxide was replaced by bicarbonate, the lead content was only 0.6 milligram per liter. Formulas are derived for calculating lead-dissolving power of water.—*R. E. Thompson.*

**Heat Balance Spots Controllable Losses.** A. A. POTTER and H. L. SOLBERG. *Power*, **68**: 1045-8, 1928. From *Chem. Abst.*, **23**: 1243, March 10, 1929. Heat losses consist of sensible heat carried away by flue gas, carbon monoxide in flue gas, carbon in ash, heat required to evaporate water of coal and to superheat water both of coal and of air, combustion of hydrogen at temperature of flue gas, and unclassified losses such as radiation, etc. Charts and equations are given from which these losses can be evaluated.—*R. E. Thompson.*

**Manufacture of Aluminum Sulfate from Clays.** I. E. ADADUROV. *J. Chem. Ind. (Moscow)*, **5**: 941-2, 1928. From *Chem. Abst.*, **23**: 1219, March 10, 1929. Clays whose alumina is mostly in form of kaolinite are most easily attacked by sulfuric acid if preliminarily calcined at 800° rather than at 700°. Clays in which the alumina is only about 34 percent in form of kaolinite are more soluble in sulfuric acid after preliminary calcination at 700° rather than at 800°. Latter clays also require stronger acid (50 percent instead of 20 percent) for solution and give poorer yield. Certain quantity of iron always contaminates product, but this impurity is less for clays rich in kaolinite than for those whose alumina is mostly not in form of kaolinite. To obtain aluminum sulfate almost free from iron it is advisable to eliminate latter by chlorination of either the crude clay or the aluminum sulfate. In treatment of crude clays iron begins to chlorinate at 300° and is ended at 400° without affecting the aluminum of clays mixed with charcoal, since latter does not begin to chlorinate below 500°. Chlorination of aluminum sulfate gives even better results but requires preliminary dehydration and expensive operation, and also a stricter regulation of temperature as aluminum sulfate begins to chlorinate just above 400°.—*R. E. Thompson.*

**A Method of Calculating Pounds of Air per Pound of Coal.** W. H. MARTIN. *Power*, **68**: 1059, 1928. From *Chem. Abst.*, **23**: 1244, March 10, 1929. Weight ratio O/C is calculated for flue gas from its composition. If one pound of fuel contains *a* pounds C, *b* pounds H and *c* pounds O, then weight of air supplied per pound of fuel =  $[(O/C) a + 8b - c]/0.23$ .—*R. E. Thompson.*

**Effect of Carbon Dioxide on Plant Economy.** B. C. SPRAGUE. *Power*, **69**: 62, 1929. From *Chem. Abst.*, **23**: 1245, March 10, 1929. Changes in percentage of carbon dioxide in boiler outlet gases should be considered in relation to temperature of outlet gases, temperature rise of water in economizer, temperature rise of air in air heater, temperature of superheated steam, combustible material in refuse of stoker-fired boilers, and amount of combustible gas in flue gas.—*R. E. Thompson.*

**Prevention of Corrosion of Pipes.** WEIGELIN. *Gas-u. Wasserfach*, **71**: 1190-2, 1928. From *Chem. Abst.*, **23**: 1098, March 10, 1929. Protective coatings for inside and outside of pipes discussed.—*R. E. Thompson.*

**Practical Corrosion Research.** E. H. SCHULZ. *Stahl u. Eisen*, 48: 1393-1402, 1928. From Chem. Abst., 23: 1098, March 10, 1929. Review of literature and outline of most important problems of practical corrosion research.—*R. E. Thompson.*

**The Structure of Water.** S. W. PENNYCUICK. *J. Phys. Chem.*, 32: 1681-96, 1928. From Chem. Abst., 23: 1033, March 10, 1929. Discussion of molecular structure of water.—*R. E. Thompson.*

**Precision Methods for the Determination of the Chloride Ion.** Y. N. SLAVYANOV. *J. Russ. Phys.-Chem. Soc.*, 60: 355-9, 1928. From Chem. Abst., 23: 1366, March 20, 1929. The VOLHARD and MOHR volumetric methods were subjected to critical study. Procedures described which will give very accurate results.—*R. E. Thompson.*

**Notes on the Precipitation of Calcium Carbonate.** R. C. EMMONS. *J. Geology*, 36: 735-42, 1928. From Chem. Abst., 23: 1370, March, 20, 1929. Experiments were carried out over period of 2-8 months to determine factors controlling precipitation of calcium carbonate. Conclusions: (1) Contact of air with water saturated with calcium bicarbonate precipitates calcium carbonate by removing carbon dioxide from solution. (2) Agitation of solution has same effect. (3) Reduction of pressure has only slight effect. (4) In quiet water calcium carbonate precipitates as fine powder, while in circulating water the calcium carbonate is coarsely crystalline.—*R. E. Thompson.*

**Latest Methods for the Complete Purification and Total Demineralization of Hard Waters.** A. The Zero Hydrotitrimetric Scale Compared with Partial Purification Methods. L. J. SUPERBIE. *Science et Ind.*, 12: 175, 88-93, 1928. From Chem. Abst., 23: 1455, March 20, 1929. Use of the hydrotitrimetric scale enables laboratory or field worker to grade accurately a water as regards its hardness. Zero on scale corresponds to entire absence of calcium or magnesium salts. One division indicates consumption of approximately 110 grams of soap per cubic meter. Precipitation methods always leave residual hardness, which is best removed by base exchange. B. Softening Apparatus for Domestic Use. PIERRE QUIQUANDON. *Ibid.*, 93-6. Home water-softening method and equipment described and illustrated. C. The Demineralization of Water Without Distillation. R. MARIE. *Ibid.*, 96-9. Good results were obtained by combined use of soda-lime and base exchange. Electroosmotic apparatus described which is relatively inexpensive on commercial scale and removes substantial part of dissolved salts. Where complete demineralization is unnecessary, as in drinking water, method may be of use. Commercial installation is described with approximate cost data.—*R. E. Thompson.*

**Chlorination in the Field of Sanitation. I. Developments in Water Purification.** L. H. ENSLOW. *Compressed Gas Manufs. Assoc.*, 1929; (preprint); C. A., 23: 1192. From Chem. Abst., 23: 1455, March 20, 1929.—*R. E. Thompson.*

**The Electrical Conductivity and Refractive Index of Water from Peat Marshes.** I. A. SMORODINTZEV and A. N. ADOVA. *J. Russ. Phys.-Chem. Soc.*, 60: 497-505, 1928. From *Chem. Abst.*, 23: 1455, March 20, 1929. Conductivity varied with mineral content while  $n$  was largely determined by organic matter. Samples obtained from carex marshes conducted 4-5 times better than those from sphagnum marshes, latter being characterized by higher  $n$ .—*R. E. Thompson.*

**Prevention of Pollution in the Upper Tame Basin (England).** F. L. WARDMAN. *Munic. Eng. Sanit. Record*, 82: 10-1, 1928. From *Chem. Abst.*, 23: 1455, March 20, 1929. Discussion.—*R. E. Thompson.*

**Growing Pains. (Municipal Work at Hinckley, England).** J. S. FEATHERSTON. *Munic. Eng. Sanit. Record*, 81: 575, 1928. From *Chem. Abst.*, 23: 1455, March 20, 1929. Water supply obtained from well in disused coal shaft has been supplemented by connecting 9-inch main to main from Thornton Reservoir of Leicester at cost of £10,000.—*R. E. Thompson.*

**Glossop (England) Municipal Works.** W. ARNOLD MITCHELL. *Munic. Eng. Sanit. Record*, 82: 40, 1928. From *Chem. Abst.*, 23: 1456, March 20, 1929. Mechanical filters will be installed at Hadfield waterworks. Hydrated lime and sodium silicate have been added to water to prevent lead solvency.—*R. E. Thompson.*

**Liquid Sulfur Dioxide, Its Manufacture, Transportation, and Uses.** CHARLES W. JOHNSTON. *Chem. Markets*, 23: 476-9, 1928; cf. *C. A.*, 22: 2800. From *Chem. Abst.*, 23: 1476, March 20, 1929.—*R. E. Thompson.*

**How to Avoid Fire in Storing Indiana Screenings.** M. A. TUTTLE. *Power*, 69: 271, 1929. From *Chem. Abst.*, 23: 1491, March 20, 1929. Foundations should be firm, level, and well-drained. Safe piling depth can best be determined by temperature observations. Segregation of fines by method of dumping employed is sometimes responsible for fires. Firmness is essential, because of better heat conductivity and less air circulation.—*R. E. Thompson.*

**Gas Works Effluent.** W. P. SMITH. *Gas J.*, 181: 690-2, 1928. From *Chem. Abst.*, 23: 1493, March 20, 1929. Subject is reviewed and discussed generally with reference to practical methods of preventing oxygen-absorbing contamination, principally phenolic and thiocyanate. Methods include minimizing time of contact between water and tar, removal of tar previously to aqueous condensation, bacterial purification methods, and dephenolation by distillation.—*R. E. Thompson.*

**Solubility of Calcium Sulfate from 0° to 200°.** EVERETT P. PARTRIDGE and ALFRED H. WHITE. *J. Am. Chem. Soc.*, 51: 360-70, 1929. From *Chem. Abst.*, 23: 1555, April 10, 1929. Values for solubility between 100° and 200° were re-determined. Within this range gypsum and anhydrite are the only stable phases. Transition temperature of gypsum to anhydrite lies near 40°.—*R. E. Thompson.*

**Indophenol Reaction in Inorganic Chemistry.** J. STIEPOVICH and A. SÄ. *Rev. Cent. Estud. Farm. Bioquim.*, 16: 384-5, 1927. From *Chem. Abst.*, 23: 1580, April 10, 1929. In indophenol test for chlorine, the production of hypochlorite is necessary, sodium or potassium hydroxide or carbonate, but not hydrogen carbonate, being added.—*R. E. Thompson.*

**Utilization of the Spectrophotometer in the Determination of Minute Amounts of Aluminum.** E. W. SCHWARTZ and RAYMOND M. HANN. *Science*, 69: 167-70, 1929. From *Chem. Abst.*, 23: 1588, April 10, 1929. Reaction between aurine tricarboxylic acid and aluminum can be utilized for determination of very small amounts of aluminum and better results are obtained with spectrophotometer than with colorimeter. Fuller details to be published later.—*R. E. Thompson.*

**Autogenous and Electric Welding.** R. W. MÜLLER. *Apparaturbau*, 41: 3-9, 1929. From *Chem. Abst.*, 23: 1604, April 10, 1929. When greatest uniformity is desired, autogenous welding is preferable; when high elasticity and toughness are desired, electric welding is better.—*R. E. Thompson.*

**The Ferric Thiocyanate Reaction as Used for Detection of Traces of Iron in Chemical Reagents.** H. W. VAN URK. *Chem. Weekblad*, 25: 703-4, 1928. From *Chem. Abst.*, 23: 1589, April 10, 1929. Accuracy of ferric thiocyanate reaction as influenced by salts was studied. In water, oxidized with nitric acid, 0.00002 per cent of iron can be detected in absence of hydrochloric acid and 0.000005 per cent, with hydrochloric acid (cf. *C. A.* 20: 3661). **The Thiocyanate Reaction Influenced by Salts.** *Ibid.*, 704-6. Decrease in color intensity of thiocyanate complex in salt solution is caused by hydrolysis due to lower pH of solution. Addition of hydrochloric acid restores color. Whereas for water the optimal hydrochloric acid concentration is 4 milliequivalents per 100 cc., amount has to be raised for salt solutions. Chlorides and nitrates have no influence; salts of weak acids have considerable influence.—*R. E. Thompson.*

**Internal Stresses as the Cause of Destruction of Construction Material.** TH. HOFFMANN. *Korrosion*, 4: 3, 1929. From *Chem. Abst.*, 23: 1607, April 10, 1929. These stresses are largely due to faulty mechanical and heat treatment during manufacture, especially in pipes of copper alloys.—*R. E. Thompson.*

**Hydrogen Ions are the Key to Corrosion.** A. A. MARKSON and PAUL FRITZ. *Power*, 69: 222-5, 1929. From *Chem. Abst.*, 23: 1609, April 10, 1929. Popular discussion.—*R. E. Thompson.*

**Treatment of Water Supplies for Generators.** P. DROUIN. *Science Ind.*, 12: 175, 100-2, 1928. From *Chem. Abst.*, 23: 1703, April 10, 1929. Incrustation of pipes and boiler tubes is very serious in France. This is prevented by distillation and by removal of hardness by base exchange. Preheating to remove dissolved gases is also desirable. Distillation is effective and economical treatment for hard waters used for steam generation.—*R. E. Thompson.*

**Fresh Water Studies. I. Relative Temperature, Oxygen Content, Alkali Reserve, Carbon Dioxide Tension, and pH of the Waters of Certain Mountain Streams at Different Altitudes in the Smoky Mountain National Park.** EDWIN B. POWERS. *Ecology*, 10: 97-111, 1929. From *Chem. Abst.*, 23: 1703, April 10, 1929. In field work carried out over period of 4 years it was found that oxygen contents increase and carbon dioxide tensions decrease with increasing altitude. Temperature, pH, and alkali reserve of waters of mountain streams decrease with increasing altitude. Without aëration, perhaps, the actual carbon dioxide content increases; the alkali reserve increases and oxygen content decreases with aging; a process which is accelerated by direct sunlight. Floods or swells at higher altitudes cause high altitude water conditions to occur at lower altitudes. Carbon dioxide tension is increased by liberation of carbon dioxide from organic substances in solution, which occurs more rapidly in sunlight than in dark.—*R. E. Thompson.*

**Preparation of a Serviceable Boiler Feed Water for High- and Super-Pressure Steam Boilers.** W. KÄRSTEN. *Chem. Fabrik*, 1929, 27-9. From *Chem. Abst.*, 23: 1706, April 10, 1929. Water with low salt content, free from carbon dioxide and oxygen, is obtained by thermochemical system (BALCKE). Carbonates are removed on plates or as sludge by settling, after heating water at atmospheric pressure. Water obtained is gas-free. Silica with some calcium oxide is harmful. Soda is added to produce soluble sodium silicate. Boiler is blown down to prevent high concentration. Treated water is kept in special closed reservoir with atmosphere of steam or nitrogen to prevent access of oxygen or of carbon dioxide.—*R. E. Thompson.*

**Conveying Coal Dust by Means of Coal Dust Pumps.** A. WIPPRECHT. *Chem. Fabrik*, 1929, 25-7. From *Chem. Abst.*, 23: 1736, April 10, 1929. Methods for conveying powdered coal outlined with special attention to FULLER-KINYON system.—*R. E. Thompson.*

**Coal Dust Firing for Boilers.** H. BERG and ERICH VOGT. *Colliery Guardian*, 138: 344-5, 1929. From *Chem. Abst.*, 23: 1736, April 10, 1929. Discussion of storage, drying, and pulverization of hard coal, and the design of combustion chambers for firing coal dust. Removal of incombustible constituents in coal by turning flame through angle of 90° or larger is suggested.—*R. E. Thompson.*

**Automatic Combustion Control for Boiler Furnaces.** *Ind. Chemist*, 5: 27-8, 1929. From *Chem. Abst.*, 23: 1735, April 10, 1929. Illustrated description of HAGAN system of regulation for boilers, which controls fuel and air supply in accordance with demand for steam and its pressure. Master regulator comprises (a) the demand detector and (b) mechanism carrying out control movement. Former is said to be sensitive to changes of pressure of couple of ounces per square inch, and latter to be very simple in operation.—*R. E. Thompson.*

**Some Results with the Hagan Automatic Combustion Control System.** T. R. ALEXANDER. *Ind. Chemist*, 5: 29-31, 1929. From *Chem. Abst.*, 23:

1735, April 10, 1929. Tests conducted on installation of 4 Babcock land-type boilers, each of 13,000 pounds per hour capacity, equipped with chain-grate stokers driven by steam engine through line shafting, are reported. Control apparatus proved itself mechanically perfect during the 7 months it was in operation, setting the controls even when variation in pressure was insufficient to show on pressure gage and maintaining pressure within 2 pounds per square inch when steam demand fluctuated 25 percent. Steadiness of carbon dioxide showed overall improvement of 1 per cent and average increase of boiler efficiency of 2.7 percent. Total savings amount to £285 per annum on coal consumption of 6000 tons at £1 per ton, thus showing good return on cost of apparatus.—*R. E. Thompson.*

**Water Consumption by Cities and Future Needs.** PAUL LHEUREUX. *Science ind.*, 12: 175, 69-73, 1928. From *Chem. Abst.*, 23: 1703, April 10, 1929. Based upon data obtained from many cities and villages in France, cities of over 60,000 inhabitants have mean per capita daily consumption of 232 liters, peak consumption 418 liters; future requirements (30 years) estimated to be 412 liters, with peak consumption of 742 liters. For cities with population of 15,000-60,000 the consumption will be generally less (180 liters, peak 324 liters). In small villages of less than 3000 population consumption is 135 liters, with peak of 190 liters.—*R. E. Thompson.*

**Calculus and the Construction of Filtering Basins in Water Bearing Strata.** PAUL LHEUREUX. *Science ind.*, 12: 175, 75-87, 1928. From *Chem. Abst.*, 23: 1705, April 10, 1929. Calculations and derivation of engineering formulas given, bearing upon location and construction of filter basins in alluvial strata containing water, near wells and rivers, in gravels, and under other conditions.—*R. E. Thompson.*

**The Filtration and Sterilization of Water for Potable Supplies.** HENRI CHABAL. *Science ind.*, 12: 175, 64-8, 1928. From *Chem. Abst.*, 23: 1705, April 10, 1929. Historical and descriptive résumé of modern filtration methods. Village of Pan had average typhoid rate of 30 cases before 1910. Upon installation of Peuch-Chabal filtration system, there was but 1 case in 2 years. Fractional filtration method is favored.—*R. E. Thompson.*

**Water at Central Steam Plants. Condensation and Feed Waters.** M. MARCHEIX. *Science ind.*, 12: 175, 103-8, 1928. From *Chem. Abst.*, 23: 1703, April 10, 1929. Automatic systems for operating distillation, feed water heater, and condensation equipment are advocated. Workable and economical steam plant hook-ups are presented. No new data.—*R. E. Thompson.*

**Coagulation Processes During the Purification of River Water. I.** C. P. MOM. Mededeel. Dienst. Volkgezondheid Nederland.-Indië, Pt. 1, 27-71, 1925. From *Chem. Abst.*, 23: 1706, April 10, 1929. Coagulation of Tjiliwong river water in Batavia by addition of 10 p.p.m. aluminum sulfate, keeping pH between 5 and 6, gave excellent results. The water carries a great deal of

color, organic matter, and colloidal clay and has low mineral content. Adjustment of pH with sulfuric acid or alkali was found necessary. Theoretical considerations underlying coagulation of colloidal silt are dealt with in great detail.—*R. E. Thompson.*

**The Determination of the Number of Colon Bacilli in Water.** A. MASSINK. Nederland. (Tijdschr.) Hgy., Microbiol., en Serol., 3: 2, 103-27, 1928. From Chem. Abst., 23: 1706, April 10, 1929. Review of methods, old and modern, of determining *B. coli* in water.—*R. E. Thompson.*

**Effluents of Factories and Cities.** J. P. LAURENT. Science ind., 12: 175, 109-15, 1928. From Chem. Abst., 23: 1709, April 10, 1929. Sugar and distillery wastes can be satisfactorily purified by double filtration and use of moderate sized sludge beds. Preliminary screening and sedimentation is desirable. Filtration followed by treatment with lime, then passing over log-wood or activated carbon beds, is recommended for dye wastes. Abattoir effluents, after screening and chemical precipitation, can be treated biologically in Imhoff tanks. Results are not always satisfactory.—*R. E. Thompson.*

**Further Research on Pipe Bends.** W. HOVGAARD. J. Math. Phys., Mass. Inst. Tech. 7: 239-97, 1928. From Chem. Abst., 23: 1781, April 20, 1929. Experimental data and analysis presented to assist in development of simple criterion for strength of pipe bends. Theory is developed that longitudinal stresses, particularly those in middle surface, determine point of breakdown of pipe bends.—*R. E. Thompson.*

**How Can the Fermentation Test of Eijkman be Improved?** A. J. VAN HOY-TEMA. Nederland. Tijdschr. Hyg., Microbiol., en Serol., 3: 2, 165-78, 1928. From Chem. Abst., 23: 1661, April 10, 1929. Spore formers and streptococci develop as well as *B. coli* in the Eijkman test; latter, chiefly, interfering with the test. On addition of secondary phosphate, the quantity of gas formed increases with the amount of phosphate and reaches maximum at about 1 percent; maximum amount of gas is considerably greater than amount obtained in normal Eijkman medium used as control; sensitiveness of 1 percent glucose, 1 percent peptone solution containing 0.1-0.2 percent dipotassium phosphate is almost as great as that of Eijkman medium; fermentations with addition of 0.1 percent phosphate apparently give clear picture of quality of water the next morning after planting. It was further found that with peptone concentrations of 0.07 percent, streptococci begin to interfere; whereas below 0.03 percent the lack of nitrogen nourishment begins to be felt. Recommended that very small amount of good peptone be employed.—*R. E. Thompson.*

**Directions for the Preparation of a "Universal Indicator" for Estimating pH Over a Wide Range.** I. M. KOLTHOFF. Pharm. Weekblad, 66: 67-70, 1929. From Chem. Abst., 23: 1587, April 10, 1929. Objections to VAN URK's universal indicator (C.A. 23: 752) pointed out. More satisfactory indicator is prepared by mixing 0.1 percent solutions of following: dimethyl yellow, 15 cc.; methyl red, 5 cc.; bromothymol blue, 20 cc.; phenolphthalein, 20 cc.; and thy-

molphtalein, 20 cc. With 0.1 cc. of this mixture per 10 cc. of solution, colors obtained at various pH values are: 1.0 rose, 3.0 red orange, 4.0 orange, 5.0 yellow orange, 6.0 lemon yellow, 7.0 yellow green, 8.0 green, 9.0 blue green, 10.0 violet.—*R. E. Thompson.*

**How Good Water is Secured for a Blast-Furnace Plant.** T. J. Ess. *Power Plant Eng.*, 33: 288-91, 1929. From *Chem. Abst.*, 23: 1849, April 20, 1929. Outline of treatment for plant using 285 million gallons per month.—*R. E. Thompson.*

**Experiments on the Changes in the Bacterial Flora of Stored Polluted Surface Water, Especially with a View to Clemesha's Method for Ascertaining the Re-cency of a Pollution.** K. HOLWERDA. Mededeel. Dienst. Volksgezondheid Nederland.-Indië, 17: Pt. II, 298-356, 1928. From *Chem. Abst.*, 23: 1706, April 10, 1929. In experiments in open reservoirs hardly any difference of titers appeared although higher Eijkman titer was general. Difference between glucose and lactose titers did not appear in samples obtained in November and December, whereas it did appear in May, June, and July, when sunlight is more profuse. In advanced purification, spore-forming, fermenting organisms often became prevalent and gave rise to irregular fermentation figures. When sodium taurocholate was added to medium most of these spore-formers do not develop. This was verified by isolation of organisms in pure culture. Experiments with water kept in dark showed no general titer difference with but slight Eijkman-titer difference. Concluded that difference in glucose and lactose titers on storage waters in open reservoirs is no general phenomenon. Extensive tabulated data given.—*R. E. Thompson.*

**Sensitive Color Reactions for Magnesium.** H. D. BARNES. *J. S. African Chem. Inst.*, 11: 67-8, 1928. From *Chem. Abst.*, 23: 1838, April 20, 1929. Neutral magnesium salt solution containing 0.5 p.p.m. of magnesium yields definite orange color when 10 cc. of solution is treated with 0.2 cc. of 0.1 percent Clayton yellow and 0.5 cc. 4 N sodium hydroxide. With more concentrated solutions (5 p.p.m.) a brick-red color is obtained. Calcium in concentrations not exceeding 300 p.p.m. does not interfere, but larger amounts produce opalescent solutions with the alkali.—*R. E. Thompson.*

**The Determination of Copper in Biological Materials.** C. A. ELVEHJEM and W. C. LINDOW. *J. Biol. Chem.*, 81: 435-43, 1929. From *Chem. Abst.*, 23: 1921, April 20, 1929. Method of BIAZZO (*C.A.*, 20: 2029) was modified. Samples containing as little as 0.02 mgm. of copper can be analyzed with accuracy.—*R. E. Thompson.*

**The Hydrology, Water Supply, and Waste Waters in the Brown Coal District of the Industrial Area in Central Germany.** P. NIEMANN. *Braunkohle*, 1927, 25: 1057 and 1102. *Wass. u. Abwass.*, 1928, 24: 264. After general hydrologic, geologic, and petrographic considerations, the author discusses the properties of a good drinking water and quotes examples from his researches on well water in the Brown Coal District of Central Germany. He discusses

also the properties and treatment of boiler feed and cooling waters, and the change in the biological composition of streams by effluents from sewers and factories.—*M. H. Coblenz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**On the Determination of Nitrogen Compounds in Industrial Waste Waters.** H. UTHE. *Vom Wasser. Ver. deutscher Chemiker, Berlin, 1927, 1: 214.* The estimation of nitrogen and its compounds is of the first importance in dealing with sewage and other effluents. The methods in common use have been mainly designed to deal with domestic sewage and show serious weaknesses when applied to some industrial waste waters where the higher concentration of foreign matters or the presence of matter difficult of decomposition may disturb the process of analysis. The usual method for nitrogen estimation is the KJELDAHL, but in extreme cases this method is not sufficiently accurate, so that the causes of failure should be found and removed, or new methods worked out. The estimation of ammonia nitrogen, even with pure domestic sewage, is not reliable and is still more difficult in the presence of considerable quantities of amines volatile in steam or easily decomposable. Many nitrogen compounds decompose on heating in alkaline solution and ammonia separates. Several suggested means of avoiding the errors thus caused are discussed including the "formol-titration" and "cold-distillation" methods. The estimation of the total nitrogen in industrial waste waters is more difficult, especially if mixed with domestic sewage. Different adaptations of the KJELDAHL process and methods for preventing the loss of nitrogen in the presence of oxygen-containing nitrogen compounds, and for estimating nitrates and nitrites are used. The influence of different cyanides and thiocyanates on nitrogen estimation is of importance especially in dealing with gas works effluents and waste waters from coke oven by-products. The value found for nitrogen in the presence of cyanides is always too high and error must be avoided by precipitation with silver sulphate.—*M. H. Coblenz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**Organisms as Indicators of the Process of Purification in a Purification Plant.** W. SCHLICK. *Int. Rev. Hydrobiol. u. Hydrog., 1925, 13: 216 and 14: 55. Wass. u. Abwass., 1928, 24: 189.* HENTSCHEL'S research on the fauna and flora of the harbour at Hamburg has shown that organisms can serve as indicators of pollution in natural waters. He did not, however, work out the relation between the occurrence of different species and the character of the pollution. In order to discover this relationship, the author investigated the mechanical and biological purification plant at Bergedorf, where he was able to examine the process of sewage purification in Emscher tanks, filters and ponds. His methods of study are described. The number and the species of organisms found in the sewage at the different stages of purification are tabulated, and curves are drawn to illustrate the relations between certain organisms and the progress of purification. Experiments were made to investigate the influence of food, temperature, and oxygen-content of water on the growth

of certain species. Some valuable conclusions were drawn, by observing the effect of these changes on the organisms present in the raw sewage and in the sewage in the filters and ponds. A bibliography is appended.—*M. H. Coblenz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**Theory and Practice in Dealing with Effluents.** H. KESSENER. *Gesund.-Ing.*, 1929, 52: 16, 248. The aim of this article is to emphasize the necessity of entrusting the erection and working of purification plants to experts, and the folly of expecting city architects, on the basis of visits to other plant, to produce satisfactory results. In America and England definite bodies of experts have arisen who have knowledge of and experience in all the branches of science concerned. Mere inspection of plants is useless. After the construction, the working of a plant must be under expert control. In England, managers have to pass an examination in theory and can gain experience in the many existing plants. The author attributes the success of many installations in Germany to the fact that their working is supervised by their builders.—*M. H. Coblenz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**Hygiene and the Problem of Sewage Disposal with Special Reference to Industrial Effluents.** O. KAMMANN. *Tech. Gemeindebl.*, 1929, 32: 36. Bad cases of river pollution are rare in Germany, but as industry extends, advantage will be taken of the costly experiments that have been necessary in England and America. The development of Rivers Boards composed of experts is advocated as the best method of control. Descriptions and illustrations of biological installations from the simple sewage farm to activated sludge processes are given. HOFER's fish pond is advocated where the necessary water is available. Brief descriptions of a few processes applicable to certain industrial effluents are given. Tanneries are instanced as likely to discharge pathogenic organisms such as anthrax spores derived from foreign hides.—*M. H. Coblenz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**Hygiene and Technique of Sewage Disposal with Special Reference to Trade Waste Waters.** *Pruss. Tech. Gemeindebl.*, 1929, 32: 25. A general review of the subject as affecting German public health work. A domestic sewage of 100-150 liters per head per day is the average for a German town. A table is given showing in round figures the proportion of impurities falling within different categories, together with the degrees of purification attainable by mechanical and biological treatments. These are only employed so far as is necessary to ensure that the total oxygen demand of effluents shall not reduce the dissolved oxygen of the watercourse below the limit for aerobic self-purification. Diagrams and illustrations of various plants for sludge separation and digestion are given and their advantages discussed.—*M. H. Coblenz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**De-phenolization of Effluents.** F.P. 630,885, Chem. Zbl., 1929, 100: 425; Wass. u. Abwass., 1929, 25: 317. It is the condensing waters which contain the greater part of the phenols found in the effluents discharged from coke plants. These waters are treated for the recovery of phenols, before passing to the ammonia still, by first removing the tar and then extracting the phenols with a solvent; benzol, solvent naphtha, or tar-oils with high boiling points. The phenols are separated from the solvent either by distillation, or by dissolving in a soda solution, and the solvent is used again.—M. H. Coblenz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).

**Treating Waste Waters.** H. WADE, E.P. 307,587, Pat. Off. J., 1929, No. 2102. Industrial waste waters are purified in successive stages, by a series of different microorganisms, derived from pure cultures, each of which decomposes a special group of polluting material: proteolytic, ammonia-forming, nitrifying, and de-nitrifying bacteria decompose the nitrogenous substances; yeasts and hyphomycetes the fats; bacteria or fungi dissolve starch or decompose dextrin and sugar and other bacteria decompose cellulose or pectin. It is advantageous to use bacteria which are in or have a tendency to form the zoogloea state. The temperature and pH must be adjusted for each different type of organism. According to one example, starch in the waste water is first decomposed into glucose or maltose by means of *Aspergillus oryzae*, *Bacillus subtilis*, or *Bacillus mesentericus*. Secondly, sugar is decomposed by treatment with yeast, and next, albumen and urea are broken down by *Bacillus putrificus* or *vulgaris* and the products converted into ammonia by *Bacillus mycoides*. Formic acid is broken up by *Bacterium formicium*, and finally the ammonia salts are oxidized by treatment with cultures of *Nitrosomonas* and *Nitrobacter*. This biological treatment may be combined with other treatment. Waste waters of different constitution are preferably kept separate for treatment.—M. H. Coblenz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).

**The Effect on Fish of Effluents Containing Cyanide.** C. LEHMANN. L. F. Fischerei, 1926, 24: Wass. u. Abwass., 1928, 24: 84. After the death of fish in the river Leine, due either to sludge containing carbide, or to an old brass bath, thrown away into the river, the author undertook experiments to test the effect of effluents containing cyanide on various fish. The fish died rapidly even in weak solutions of cyanide, containing only 0.2 p.p.m. This is not surprising as potassium cyanide is a very poisonous substance. The effluents from coke plants and gas works are a source of danger to fish, owing to the presence of compounds containing cyanogen. The author suggests other possible sources of cyanides and ferrocyanides, and describes some of the experimental work, carried out in the Emscher district on the treatment of these effluents.—M. H. Coblenz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).

**Coagulation of Colloidal Solutions.** A. BOUTARIC. J. pharm. et chimie, 1928, 7: 456. Rev. Générale des Colloïdes, 1929, 7: 25. The author, after describing a method for measuring the stability of a colloidal solution, gives a systematic survey of the factors which are able to influence stability. It was noted that stability is connected with the internal structure of the colloid, that it varies according to the external conditions and is altered by the presence of small quantities of foreign substances. The phenomenon, that small quantities of an electrolyte added to a solution protect it from coagulation, while larger doses of the same electrolyte cause coagulation, was studied and the possibilities of finding a method of changing the electric sign of colloids, and repeating this change at will a great many times were also considered.—M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).

**New Enzyme, Glucose-Oxidase.** I. D. MÜLLER, Biochem., Ztg., 1928, 199: 136-170. The following active enzyme preparations were obtained from *Aspergillus niger*: (1) the expressed juice from the ground mycelium; (2) a dry powder obtained by treating the juice with 12 vols. of 96 per cent alcohol-ether (2: 1); (3) a dried mycelium preparation obtained by treating the pressed mass with alcohol-ether. A molecule of dextrose absorbed approximately one atom of atmospheric oxygen, giving rise to 1 equivalent of fixed acid which consisted, probably entirely, of *d*-gluconic acid.—M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).

**The Production of Citric Acid by Fermentation Processes.** F. CHALLENGER. Industrial Chemist, 1929, 5: 181. WEHMER, in 1890, discovered that *Mucor piriformis* produced citric acid when grown in solutions of cane sugar or glucose. *Aspergillus* and *Penicillium* are used nowadays for the production of citric acid. From a chemical point of view this change from glucose to citric acid is unique, because it involves the formation of a branched chain. Various hypothesis have been put forward to explain this change. Details of the chemical reactions suggested by various workers and their confirmation, if any, by fermentation experiments are given.—M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).

**Method of Formation of "Barégines" in the Sulphur Wells at Barèges and the Action of Micro-organisms.** P. FOURMENT, Comptes Rendus de la soc. d. biol., 1928, 99: 326; Zentralbl. f. d. ges. Hyg., 1928, 18: 775; Wass. u. Abwass., 1929, 25: 294. The gelatinous masses, termed "barégines," found in the sulphur wells at Barèges are chiefly composed of threads of *Thiothrix*. The tips of the threads are filled with grains of sulphur, while the lower parts are dead. After the *Thiothrix* has formed spores and consequently ceased to grow, other organisms, such as *B. fluorescens liquef. micrococcus*, torula, and mucors, cause the grains of sulphur to collect together, and sulphur is deposited in the form of crystals inside the mass of slime.—M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).

**A Contribution to our Knowledge of Disinfectant Action. III. Unsaturated Compounds as Germicides.** H. D. CHEESEWORTH and E. A. COOPER. *J. Physical Chem.*, 1929, 33: 720. Experiments were undertaken to discover the relation between chemical constitution and germicidal power by means of a comparative study of the toxic action of unsaturated and saturated compounds upon micro-organisms. Aliphatic unsaturated compounds and their related saturated derivatives and phenols and cyclohexanols were used, and their bactericidal power was measured both by the CHICK-MARTIN method, in which the disinfectant action is measured every 30 minutes, and also by the inhibitory method, in which measurements of the capacity of a substance to restrain bacterial growth are taken every 48 hours. Tables of results, obtained by both methods, of the concentrations of the compounds necessary to destroy certain bacteria under special conditions of temperature etc., are given. Further experiments were made to investigate the factors governing this disinfectant power of the compounds. According to LEPESCHKIN, *Biochem. Z.*, 1926: 171: 126, a compound is bactericidal because it possesses the power of breaking down the combination between the protein and lipin constituents of the protoplasm. Experiments were devised to test the precipitating action of the compounds on egg albumin, and lecitho-vitellin. The relative precipitating power of the disinfectants was found to be in about the same order as their bactericidal power. From a study of the action of allyl alcohol on proteins, no evidence was obtained of any chemical reaction through the unsaturated grouping. It is therefore suggested that the greater power of unsaturated substances is associated with a greater physico-chemical capacity to induce precipitation in the colloidal suspensions of the cell proteins.—*M. H. Coblenz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**Trentabank Reservoir: Macclesfield, England, Corporation Waterworks.** Anon. *Water and Water Engineering*, 31: 372, 556-560, December 20, 1929. Urgent need for more water resulted in plans to secure it by construction of the Trentabank Reservoir, which project received Royal Assent in 1923 and was estimated to cost almost \$1,000,000. The works include an earthen dam with concrete-refilled cut-off trench and puddle-clay core, a 15-inch pipe line, a tunnel and over-flow shaft, and a valve shaft. The dam contains 116,000 cubic yards and the core, 9000. Construction difficulties are cited. All farms on the drainage area have been purchased and afforestation will probably be undertaken.—*Arthur P. Miller.*

**The Conversion of Inferential Meters into Positive Meters. Device Now to be used by Metropolitan Water Board.** Anon. *Water and Water Engineering*, 31: 372, 560-561, December 20, 1929. A patented device to convert inferential into positive meters is described by detailed reference to sketches. It is being installed by the Metropolitan Water Board. [Whether for testing purposes only, or as a routine measure, is not stated.—ABSTR.]—*Arthur P. Miller.*

**Friction Loss in Lined Water Pipe.** Anon. *Water and Water Engineering*, 31: No. 372, 561, December 20, 1929. The University of Illinois conducted

tests to determine the relative losses of head in cement-lined and tar-coated cast iron pipe. The relative smoothness of the two coatings is shown by the following values found for *C* in the HAZEN and WILLIAMS formula from the tests, figured for a velocity of 3.14 feet per second:

|                        | Internal diameter<br>inches | Value found<br>for <i>C</i> |
|------------------------|-----------------------------|-----------------------------|
| Cement lined pipe..... | 3.61                        | 149                         |
|                        | 5.84                        | 151                         |
|                        | 7.86                        | 150                         |
| Tar coated pipe.....   | 3.96                        | 134                         |
|                        | 5.88                        | 140                         |
|                        | 7.97                        | 132                         |

Arthur P. Miller.

**Water Supply as a Factor in Town and Regional Planning.** G. L. PEPLER. *Water and Water Engineering*, 31: 372, 562-564, December 20, 1929. The water engineer and the town planner are both interested in catchment areas, the former in preventing their pollution and the latter in keeping them free from building so as to have great open spaces. On the other hand, the town planner objects to the submerging of forest lands to provide water for far distant cities. Another matter of common interest to them is the permissible extent of the recreational uses of catchment areas and reservoirs. Regional planning may assist in keeping a limestone watershed free from dense building thereby avoiding potential pollution. Or, when a river source is involved, it may be found desirable to segregate a riverside development. The town planner prefers compact settlements of loose texture surrounded by real country. This makes for an economical water supply system. Zoning, with its restriction on classes and heights of buildings, has a decided relationship to water needs and consumption. On the whole, town planner and water engineer have many problems of joint interest.—Arthur P. Miller.

**Saunton, England, Water Supply. Wind-Driven Pumping Plant.** Anon. *Water and Water Engineering*, 31: 372, 569-570, December 20, 1929. At Saunton, North Devon, there is in operation what is thought to be the largest modern wind-driven pumping plant in England. The 45-foot wind wheel is suitably connected to a borehole pump over a 9-inch borehole. An oil engine is the standby.—Arthur P. Miller.

**Ewden Valley Reservoirs and Works. Sheffield Corporation Waterworks.** WILLIAM TERREY. *Water and Water Engineering*, 31: 371, 501-505, November 20, 1929. This article describes the construction of two reservoirs, completion of which marked an important stage in the development of the works undertaken by the Sheffield Corporation to secure the maintenance of a good water supply for that city and district. No unusual difficulties were encountered in the construction of the Broomhead and More Hall reservoirs. The filtration plant includes 32 pressure filters having a total capacity of 4,000,000 gallons per day. The filtration building is large enough to accommodate 24

additional filters, which would increase the daily capacity to 7,000,000 gallons. Neither the other features of the plant, nor its operation, seem to be unusual.—*Arthur P. Miller.*

**Rhyl Urban District Council Water Undertaking. New Pumping and Filtration Works.** Anon. *Water and Water Engineering*, 31: 371, 507-511, November 20, 1929. In 1921 the resources of the Rhyl Urban District Council water undertaking were severely taxed by a drought and hence plans were made to avoid such a situation in the future. A new mechanical filter house was built containing four Candy horizontal pressure filters of the latest model with total daily capacity of one-fourth million gallons, with ample space for a fifth filter. Application of chemicals and operation of the filters are as usual. After coagulation and filtration the water is chlorinated. Description of a new pumping station built to augment existing supply from the Aled stream and of the engines therein installed is given.—*Arthur P. Miller.*

**Kempton Park Works. New Pumping Station and Primary Filters of Metropolitan Water Board.** Anon. *Water and Water Engineering*, 31: 371, 511-514, November 20, 1929. In this article, which is continued from the preceding issue, the pumps and auxiliaries, such as compressors, are described. Firing equipment is of the latest type, the coal being automatically weighed and fed to the grates through chutes from overhead bunkers. Ashes and clinkers pass over the backs of the stokers into cast iron tanks from which they are carried by conveyor belt into a bucket elevator delivering into storage bunker. Automatic electrical CO<sub>2</sub> recorders, pyrometers, pressure gauges, and recorders are in use.—*Arthur P. Miller.*

**Reservoirs (Safety Provisions) Bill.** Anon. *Water and Water Engineering*, 31: 371, 514-515, November 20, 1929. In the interests of safety, a bill was read for the first time in the House of Commons on October 31, 1929, which would impose precautions to be observed in the construction, alteration, and use of reservoirs, and amend the law with respect to liability for injury caused by the escape of water from reservoirs. The principal provision of the Act is to the effect that large reservoirs must be designed by, and constructed under supervision of, qualified civil engineers. Other sections of the bill indicate when and under what conditions a reservoir may be filled with water.—*Arthur P. Miller.*

**Testing of Yield of Borehole for Mid-Kent Water Co.** Anon. *Water and Water Engineering*, 31: 371, 520-522, November 20, 1929. This article describes what is believed to be the first test of its kind conducted in England to prove borehole yield, namely, by means of a borehole centrifugal operated by electricity on the potentiometer principle. Including the preliminary test, the plant ran 375 hours, producing about 7½ million gallons of water. Twenty tons of sand were removed from the receiving chamber during and after the test which was considered successful and as indicating that better results can be obtained with modern plants by up-to-date tests than by older methods.—*Arthur P. Miller.*

**Present-Day Centrifugal Pumps.** C. PFLEIDERER. *Water and Water Engineering*, 31: 371, 526-529, November 20, 1929. In this article is described in a semi-technical way the extended field of application of centrifugal pumps, as likewise their efficiency, duty, and power. Quite a number of installations requiring special designs are cited.—Arthur P. Miller.

**Moving a Cement-Jointed Water Main.** Anon. *Public Works*, 60: 382, 1929. A cement-jointed water main under 90 pounds pressure was lowered in the following manner. A trench 5 or 6 feet wide was dug along and slightly lower than the main. The cement joints were chipped out for a distance of approximately 2 inches from the bell which was then filled with lead, but not caulked. Excavation was then carried below the pipe for about eighteen inches leaving a rib of soil two feet wide at each joint. Scraping the rib out two or three inches at a time gradually lowered the pipe the required amount. Occasional leaks were stopped by use of a pneumatic calking tool.—C. C. Ruchhoft.

**Developments in 1929 in the Chemical Treatment and Filtration of Water.** JOHN R. BAYLIS. *Water Works and Sewerage*, 76: 512-14, December, 1929. The year 1929 is one of noteworthy achievements. The research and the large number of articles on the subject are evidence of the interest displayed. All this work is not without satisfactory and encouraging results, for water-borne diseases have been reduced almost to a minimum. Seventy-four cities with a population of 26,737,000 reported 1,796 deaths from typhoid fever in 1918, while these same cities, having a total population of 33,116,000 in 1928, reported 627 deaths from the same cause; a reduction of over 70 percent. Efforts have not been spared to produce water of very high quality and free from objectionable tastes. The work of HOWARD at Toronto on taste elimination involves chlorination to excess and then dechlorinating with sulfur dioxide. Ammonia, potassium permanganate, and activated carbon have been used as means of eliminating tastes and odors. "Ammonia prevents the formation of chloro compounds that produce disagreeable tastes. Potassium permanganate and superchlorination oxidize certain taste-producing compounds, whereas activated carbon absorbs the compounds." A combination of these is very effective, as passing superchlorinated water through activated carbon beds. Water can be treated for taste elimination at the low cost of \$1.50 per million gallons. In the treatment of corrosive waters lime, soda ash, sodium hydroxide, and sodium silicate have been used. For hard water any one of the forenamed compounds is suitable; but lime is cheapest. Lime is best for very soft waters. Treatment for water softening has become quite extensive. Water with 10 to 15 p.p.m. of magnesium is treated with an excess of lime to produce a pH of 10.5 to 10.8 so as to precipitate magnesium hydroxide. The caustic alkalinity, composed largely of calcium hydroxide, is converted to carbonate with carbon dioxide. Zeolite is extensively used where a very soft water is needed. In coagulation of water the major development was made by MOHLMAN and PALMER who found that chlorine added to a solution of ferrous sulfate produces ferric sulfate and ferric chloride which together will effect coagulation at a lower pH than will ferrous sulfate alone. Precipitation will take place when

the pH is between 5.0 and 11.0. With aluminum sulfate, precipitation occurs in a narrower range. Laboratory tests have been given more attention. The pH test is now in wide use and instruments to measure turbidity, laboratory filters, stirring machines, and other experimental apparatus are found in almost all the leading water laboratories. Water much better than the standard requires has been the aim in many plants. The present standard of 1 *B. coli* per 100 cc. is superseded in many plants and water having not more than 1 *B. coli* per 1000 cc. aimed at. BAYLIS suggests that bacteriological tests are unnecessary if there is a residual chlorine of 0.3 to 0.5 p.p.m. two or three hours after application; for this insures a safe water. The construction of new filter plants has progressed at the usual rate, more than twenty having been put in operation during last year. Plants are being more generously equipped and more attention is being paid to exterior attractiveness. There have been no major developments in design. Plants are installing dry feed machines for applying chemicals to water, means of handling and storing chemicals, air conveyors, sludge removing devices, and mixing basins. There have been no great changes in the design of filter beds. Efforts have been made to alleviate filter clogging troubles by expanding the sand with a high rate of wash. The method of surface wash is perhaps the best solution for filter clogging. Chlorine is being used in a variety of ways and there are still numerous possibilities for its further use.—C. C. Ruchhoft (*Courtesy Chem. Abst.*).

**Dubuque's Air Lift Pumping Plant.** J. W. McEVoy. *Public Works*, 60: 384-5, 1929. Initial system consisted of 8-inch suction wells 100 feet deep and four artesian wells over 1500 feet deep having a natural flow of 1 m.g.d. Calculations showed that by lowering the water level to a depth of 100 feet below the ground surface 5,100,000 gallons daily could be pumped from the artesian wells. The air lift equipment consists of two units, 12- by 14-inch compressors driven by 400 h.p. synchronous motors. Tests on the system showed a total pumpage of 6,475,000 gallons daily against an average lift of 128 feet. Air consumption was 0.442 cubic feet per gallon of water. Total horse power required was 412.—C. C. Ruchhoft.

**Slush Ice in Seattle Water Supply.** Anon. *Public Works*, 60: 375-6, 1929. Slush ice forming under the surface ice stopped intake openings sufficiently to cause collapse of the wood stave penstocks. An air distributing pipe was installed below the lowest row of intake openings and offset ten feet from the face of the dam. A seven- by six-inch portable air compressor furnished the necessary air at a pressure of 100 pounds per square inch. No more trouble was experienced after using this apparatus.—C. C. Ruchhoft.

**Construction of Wanaque Aqueduct.** A. A. JONES. *Public Works*, 60: 331-5 and 379-81, 1929. The Wanaque Aqueduct now under construction in Passaic County, New Jersey, is designed to carry water from the impounding reservoir to the Belleville reservoir near Newark. The total length is approximately 20.5 miles. The aqueduct is designed to furnish an annual average of 100 m.g.d. to eight municipalities. Leaving the gate house at the Wanaque Dam the first two hundred feet of line is 84-inch steel pipe placed in an open cut.

This is followed by 1100 feet of lock-joint concrete pipe laid inside Wanaque tunnel. A Y chamber at the lower tunnel end divides the aqueduct into two steel lines of 74-inch lock-bar pipe which extend for 14 miles finally converging at the mouth of the Great Notch tunnel into a single line of the same size. Major portion of construction work is cut and cover, with concrete pipe-casings at stream crossings. Twin lines are spaced nine feet on centers and require a trench 16 feet wide. A six-foot trench carries the single line. Minimum fill of three feet is prescribed. For the twin line portion, five equally spaced cross-connection chambers are specified. Each contains five 48-inch valves arranged in the form of an H. Drainage manholes are provided at low points and automatic air valves are located at summits. All valve chambers are vented with one or more 12-inch cast iron pipes rising to six feet above ground level. All steel pipe is coated and wrapped with felt wrapping. Expansion joints are provided only at cross-connection chambers. Each pipe entering the valve chamber is provided with a 74-inch by 48-inch reducer. A steel caulking ring, 1 inch by 11 inches, attached to the pipe with countersunk rivets enters the bell of a cast steel bell-and-flanged connecting piece which in turn is bolted to the 48-inch valve. The connecting piece bell is 9 inches deep and is provided with two caulking grooves; the ring on the steel pipe being smooth allows the necessary expansion and contraction. The Wanaque and Great Notch tunnels previously built were lined with plain concrete and were unreinforced. Twelve foot sections of 84-inch steel pipe were used for this purpose. A six-wheel tunnel truck mounted on narrow gauge track was used in pipe laying and this was followed progressively by caulking of the lead joints. The four-inch space between the steel pipe and the horse shoe shaped tunnel lining was filled with concrete up to the springing line. Shop tests require absolute water tightness under hydrostatic pressure of 175 pounds per square inch. Field test requirements are a pressure of not less than 100, nor more than 125 pounds and a total leakage not exceeding 8500 gallons per mile in 24 hours. The fifty thousand feet of pipe already tested shows an average leakage of 7400 gallons per mile per day.—C. C. Ruchhoft.

**Designing Rapid Sand Filters.** A. W. LIVINGSTONE and E. W. BACHARACH. Public Works, 60: 385-7, 1929. Rapid sand filters were originally circular in shape and wood or steel in construction, but present practice favors a rectangular concrete tank. The rectangular shape eliminates waste space, serves better as foundation for the enclosing building, and is better adapted for efficient under-drainage and wash water distribution. The filter length should be 20 to 30 percent greater than the width, in order to shorten the pipe gallery and operating floor and to facilitate adaptation of wash water troughs and strainer system. A common standard size for a filter unit is twelve by fifteen feet, having a capacity of one-half million gallons per 24 hours. Patterns for under-drains and wash water troughs for this standard size are carried by all equipment manufacturers. Filter capacity is usually based on a rate of flow of two gallons per minute for each square foot of sand bed area. For clarification only, the rate may be increased to three or four gallons per minute. With highly contaminated water, or with a settling chamber of low efficiency, the rate should be reduced below two gallons per minute. Originally under-

drains performed three functions: (1) collected the filtered water, (2) distributed wash water, and (3) prevented passage of fine sand from the filter bed. The last was accomplished by means of a strainer system. A properly graded gravel bed can be relied upon to take the place of a strainer system and the old method of perforated pipe laterals is considered quite as good as any modern type. A typical gravel bed is described as follows: first, four inches of gravel passing a screen with circular openings of 2.5 inches and retained on one of 1.5-inch openings; next, four inches of 1.5 to 1-inch gravel; and finally three inches of one-fourth- to one-twelfth-inch gravel. On the gravel is placed the filter sand, generally to a depth of thirty inches. This should have a high specific gravity; effective size between 0.40 and 0.50 mm.; and uniformity coefficient not to exceed 1.7. Wash water troughs should be of sufficient size to carry off the wash water freely when running not quite full. Top edges of all troughs should be absolutely level and in the same horizontal plane in any one filter. The distance of the edge of the trough above the sand depends upon the rate of wash water to be used. Troughs are generally placed 3.5 feet apart. In order to secure uniform high efficiency, rate of flow must be kept constant and within the limits of the filter capacity. This is accomplished by use of an effluent rate controller for each unit. Hydraulically operated valves are preferable to those electrically or manually operated. *C. C. Ruchhoft (Courtesy Chem. Abst.).*

**The Painting of Water Tanks.** A. H. SABIN. *Public Works*, 60: 445, 1929. The importance of painting the interior of water tanks cannot be emphasized too much. If this is done when tank is first constructed, trouble from leaks, rust, and other inconveniences can be avoided for many years. Three coats of the best paint should be applied upon a perfectly conditioned steel surface. For general painting, the first coat should be least elastic and each succeeding coat more elastic, that is, containing more oil. This is to make all coats finally acquire the same hardness, thus allowing contraction and expansion without cracking. Under water, the conditions are reversed: the outer coat should be the hardest. This is done by adding more pigment. With red lead, five or ten percent more litharge is added. The first coat may consist of a heavy red-lead paint, the second coat should contain a little litharge, and the third, the full amount. The litharge is added and mixed shortly before applying. Litharge should not be used in the paint for the outside of the tank.—*C. C. Ruchhoft.*

**Leveling for Tunnels and Reservoirs.** LEROY G. HARRIS. *Water Works and Sewerage*, 76: 521-22, 1929. In the surveys made for the Swift River Reservoir of the Boston Metropolitan District water supply, the base for levels was established by running "precise" or "first order" levels from a Government bench-mark at Springfield, Mass., along railroads to Boston. Permanent bench-marks were established at intervals of about 2 miles and temporary ones in between where necessary. The temporary bench-marks were made so that in case of error the entire 2 miles would not have to be re-run. A permanent bench-mark was so designated when it was fastened in rock, brick, or concrete. At points where extensions might be made in the future, bench-marks were

established within a radius of about  $\frac{1}{2}$  mile. All lines should be leveled independently in both forward and backward directions, the backward measurements should be made under different atmospheric conditions, and checks made. The length of sight, usually determined by topographic conditions, should not exceed 400 feet in either direction. Bench-marks used were either a  $\frac{1}{4}$ -inch round brass rod, 6 inches long, rounded on one end and threaded for 3 inches on the shank, or an iron rod 5 feet long and bent on one end. The first was grouted into large boulders of abutments and the second, set in concrete and protected. The work is best done in the summer months. Leveling distances should be equalized at all times and readings made quickly.—C. C. Ruchhoft.

**Sources of Water Supply in Southern California.** A. L. SONDEREGGER. *Water Works and Sewerage*, 76, 12, 527-31, December, 1929. The water supply of Southern California depends upon the rain falling on its contributory watershed. Moisture-laden storm winds which drift in from the Pacific Ocean striking the coast from southeast, south, and southwest, strike the mountains and are forced to higher altitudes where they are cooled and precipitate a large portion of their moisture. There is no regularity in the periods of rainfall in this region from year to year, but there are long cycles of wet and dry periods, lasting 20 to 24 years. Part of the rainfall seeps into the ground, finally to reach the streams, some evaporates, and the rest is known as "storm runoff." The runoff of a mountain watershed, which includes the seepage and storm runoff, is part of the source of water supply. A recharge from ground water basins occurs later and in certain spots adds considerably to the supply. The greater part of Southern California is underlain by water basins from which 75 percent of the water supply is derived by means of wells.—C. C. Ruchhoft.

**The East Providence Water Company.** ALBERT C. DICKERMAN. *Journ. New Eng. W. W. Assoc.*, 43: 3, 239-45, September, 1929. The Company supplies part of the town of New Providence, Rhode Island, with population of approximately 12,000. The water is obtained from Ten Mile River, a stream rising in Massachusetts and draining an area of approximately 53 square miles above pumping station. The water works consist of pumping station and filter plant of 3 m.g.d. capacity. Advantage is taken of a fall of 22 feet in the river, which provides gravity flow to filters and enables the company to generate part of power for pumping. A 144-k.w. generator directly connected to 225-h.p. Leffel water wheel delivers as much power as stream will furnish; remainder is purchased. The hydro-electric unit also provides stand-by service available in any emergency when central station connection may be severed. [NOTE. Since above paper was written the water company has been purchased by Town of East Providence; see following Abstract.—ABSTR.]—H. H. Gerstein.

**The East Providence Water Company Rate Case.** ALBERT C. DICKERMAN. *Journ. New Eng. W. W. Assoc.*, 43: 3, 246-57, September, 1929. The East Providence Water Company made a determined effort to increase water rates, in order to obtain sufficient revenue to provide for the proper maintenance of

system and to pay reasonable return on investment. After a number of hearings before Rhode Island Utilities Commission and extensive litigation, the case was terminated by the acquisition of the water company by the town.—*H. H. Gerstein.*

**The Shepaug Tunnel, Waterbury, Conn.** R. A. CAIRNS. *Journ. New Eng. W. W. Assoc.*, 43: 3, 258-72, September, 1929. Project for providing additional water supply for City of Waterbury, Conn., involved construction of 37,024 feet of tunnel, mostly through rock. The work was carried on entirely by the Municipal Bureau of Engineering. Description is given of tunneling methods used. Unit costs were: driving rock tunnel, \$43.12 per foot; concrete invert lining, \$10.03 per foot; concrete arch lining, \$21.02 per foot. At beginning of operations, advance of 6 feet per shift was apparently the limit of human endurance. However, with introduction of system of wages based on minimum progress of 6 feet per shift, with pay increases in direct proportion to progress, progress increased to from 10 to 11 feet per shift.—*H. H. Gerstein.*

**The Maintenance of Water Meters.** H. W. GRISWOLD. *Journ. New Eng. W. W. Assoc.*, 43: 3, 273-80. September, 1929. The successful program for maintenance of small water meters involves the consideration of the following factors: (1) frequent inspection of meters in service to detect those not registering, or over-registering; (2) prompt removal and replacement of "down" meters with minimum of lost motion; (3) testing of meters at regular intervals; (4) application of efficient factory methods to repair shop and testing bench; (5) close control of records and stock, so that there will be enough, but not too much.—*H. H. Gerstein.*

**Installation and Care of Venturi Meters.** A. B. COULTERS. *Journ. New Eng. W. W. Assoc.*, 43: 3, 281-3, September, 1929. Installation of a Venturi meter tube presents no greater difficulties than installation of an equal length of pipe. Where ground conditions are such that settlement is liable to occur, tubes should be made with bell and spigot instead of flange joints on outlet cone. The most durable pipes for pressure lines are those of brass, or copper.—*H. H. Gerstein.*

**Factors in the Design of Distribution Systems.** V. BERNARD SIEMS and D. BENTON BISER. *Journ. New Eng. W. W. Assoc.*, 43: 3, 284-97, September, 1929. The design of a distribution system falls into three major categories: (1) the importance and relation of contemplated system in the general scheme of water supply development for particular geographic areas; (2) the character and future possibilities of community for which system is contemplated; (3) calculation of required capacity of system in accordance with one of the stated methods, based upon the development characteristics of the community. For larger cities the authors recommend a design based on future fire-protection requirements and offer formula which takes into account the various factors involved in fire-protection demand.—*H. H. Gerstein.*

**Public Water Supplies of Connecticut.** WARREN J. SCOTT and F. O. A. ALMQUIST. *Journ. New Eng. W. W. Assoc.*, 43: 3, 298-317, September, 1929. Presents statistics relative to the various public water supplies of Connecticut, such as source of supply, method of treatment, length of mains, etc.—H. H. Gerstein.

### NEW BOOKS

**Proceedings of the Third Annual Michigan Conference on Water Purification, Bay City, Michigan, September 17, 18, 19, 1928.** Michigan Department of Health, Lansing, 59 pp. **Chlorination.** C. H. BURDICK, 7-18. Application of chlorine in water treatment should be gauged by residual chlorine test. Practice varies considerably in amount of residual chlorine to be carried in filtered water supplies. Water from the Great Lakes may be safely controlled with residuals of 0.01 p.p.m. The inland river systems of the State usually require much more. Flint, treating highly colored water, uses residuals of .15 to .20 p.p.m. after 15 to 20 minutes contact. Since the *o*-tolidin test is founded on an oxidizing reaction, other oxidizing agents interfere. Data are given showing effect of the time of contact of chlorine upon bacteria in Flint tap water. **Discussion.** HULBERT, Detroit, cites instance where chlorine dosage at rate of 15 pounds per million gallons (2 p.p.m.) failed to eliminate bacteria in water passed through new mains and no residual chlorine remained. BILLINGS, Grand Rapids, states that prechlorination has been practiced at Grand Rapids since the plant was built. Chlorine applied 5 to 10 minutes before water goes to filters with no ill effect on filter efficiency or on condition of alum mat. **Water Bacteriology and B. Coli Index.** W. M. WALLACE, 18-26. Routine tests made at Detroit plant are 20°C. and 37°C. agar counts, lactose broth inoculation from which gas forms are transplanted to brilliant green bile broth, with subsequent transplantation to eosine methylene blue plates. The brilliant green bile broth seems to inhibit growth of some organisms which cloud attempts to isolate the colon group. **Discussion** indicates that most of the small plants in the State report the *B. coli* index as determined by the PHELPS method. **Tastes, Chemical.** LOUIS B. HARRISON, 26-29. One of the most serious problems of modern water purification is that of the elimination of unpleasant tastes. Chemical tastes are due principally to reaction of chlorine with phenols or creosotes in the water resulting from sewage or industrial waste pollution. The problem may be attacked from two angles; one, keep the objectionable taste-producing substances from the streams; two, prevent the formation of the chlorine compounds at the water plant. There are several available means for effecting the latter purpose, among which are superchlorination and dechlorination, treatment with ammonia and chlorine and with potassium permanganate. In superchlorination and dechlorination treatment, the chlorine dosage varies from 3.2 to 3.0 p.p.m.; the lower the temperature, the larger the necessary dosage. Dechlorination is effected by feeding sulphur dioxide through chlorine machines. This method has been used at Bay City with success when the organic content of the water is low but without success when the oxygen consumed value rose as high as 7 p.p.m. In the treatment with ammonia in conjunction with chlorine it is essential that

the ammonia be applied and thoroughly mixed with the water before the chlorine is applied. The rate of ammonia application is about 0.25 p.p.m. The use of chloramines requires application at but one point. In the permanganate treatment the permanganate may be added first and after a short period of contact chlorine is applied, or it may be applied with or following the chlorine. The usual dosage is 0.25 to 1.0 p.p.m. **Taste, Biological.** LLOYD C. BILLINGS, 29-35. Biological tastes ordinarily originate from two principal causes; (1) those produced by dead and living organisms without chlorine; and (2), those produced by these organisms combining with chlorine. The Grand Rapids plant was put in service in 1912. During the first five years it was operated as a complete softening plant, using lime and alum as coagulant, with prechlorination in the settled water. There were no tastes whatever during this period, the organisms apparently being removed by the heavy chemical treatment. During the second five years the water was only partially softened and coagulation was incomplete. Prechlorination was practiced and objectionable tastes were produced occasionally. During the third five years partial softening was practiced, additional open settling basins were added and the water was prechlorinated. During this period there were many taste troubles and filter runs were materially shortened. In 1927 it was observed that when the settling basins were laden with sludge during the heavy summer operation there were no taste troubles, but after the fall cleaning, when the inhibiting effect of the sludge on algae was reduced, the tastes returned. It was possible to eliminate the tastes by applying chlorine to the water on the filters instead of in the settling basins. In 1928 studies showed that a direct relation existed between microscopic count and length of filter runs. Algal growth has since been kept down in the settling basin by treatment of the water with lime to causticity for a period of 24 to 48 hours once each week. Superchlorination has been tried without success. The best results seem to be obtained when the organisms are coagulated and removed from the water by sedimentation. **Chlorophenol Tastes.** HARRY G. HELGESON, 35-36. Alpena takes its supply from Lake Huron at a point about three quarters mile south of the mouth of Thunder Bay River which carries sewage and industrial wastes of the City out into the lake. Gas plant wastes are discharged into the lake near the intake. Chlorophenol tastes in the water supply follow east or northeast winds at times when the water is close to freezing or under an ice sheet. No remedy has been found in this particular case. **Some Experiences with Microscopic Organisms.** W. J. ELDRIDGE, 37-39. Iron Mountain secures its water from two sources, a small shallow lake one and one-half square miles in area and a highly polluted and very hard underground water from a mine. The lake water is generally preferred and used about nine months of the year, but because of tastes developed by microorganisms in this water, the underground water must be used during the summer months. The relation between microscopic organisms and bicarbonates is well indicated in this case. During June a fishy odor, due to *Dinobryon*, is developed which gradually changes to a musty odor, which may be due to *Nitzschia*, but more probably to the decomposition of organisms of various kinds on the bottom of the lake. Similar odors are noted when coagulation basins at the filter plant are cleaned. Both odors are intensified by chlorine. *Nitzschia* appears to shorten filter runs due

to clogging of bed and hampers settling due to its buoyant effect upon the floc. Mud ball troubles have occurred with lake water due to the formation of an aggregation of alum and microorganisms which is not broken up and washed away by the ordinary rates of filter washing. **Swimming Pool Sanitation.** R. J. FAUST. 40-48. There are two principle types of pool installation; the fill and draw, and the circulating. There are two principal types of filters used for pool waters; the pressure filter, and the gravity filter. The pressure filter is usually composed of 24 to 27 inches of sand upon 12 inches of gravel, and is operated at a normal rate of about 3 gallons per square feet per minute. The wash rate carries from 10 to 15 gallons per square foot per minute for a period from 10 to 60 minutes. Most filters in Michigan pools have inadequate filter area to give the desirable 12-hour turnover. Gravity sand filters are particularly suited to large pools. They are ordinarily built with 12 inches of sand or 18 inches of gravel, and are operated at a rate of about three-fourths gallon per square foot per minute. The principal sanitary protection of pools is disinfection. Of the 87 indoor pools in Michigan, exclusive of Detroit, 27 use liquid chlorine; 26, chlorinated lime; 17, ultra-violet ray; 6, sodium hypochlorite; 3, copper sulphate; 2, ozone; and 6, nothing. Liquid chlorine fed through a chlorinator is the best pool water disinfectant. Water should carry 0.2 to 0.5 p.p.m. residual chlorine to control pollution without causing irritation of mucous membranes. Chlorinated lime is popular because of its low first cost, but is unreliable, inaccurate, and variable. Installations of this type are being abandoned. Ultra-violet rays are effective only with clear waters. The turbidity of pool water makes this process unsuited for heavily loaded pools. Sodium hypochlorite is now produced by an electrolytic process. The first cost is slightly higher than liquid chlorine. The results are satisfactory. Copper sulphate is applied by dragging a sack of it through the water. It is not highly satisfactory and this process is not advised. Ozone has two marked advantages; first, it oxidizes all organic matter and thus clarifies it; and second, the escaping gas deodorizes the air of the pool room. Algae are a problem in outdoor and sky-lighted indoor pools. Treatment with about  $\frac{1}{2}$  pound of copper sulphate per 100,000 gallons of water is usually effective in reducing algae. Standards of clarity and of bacterial content of pool waters are becoming more stringent, due to an increasing popular demand for better pool conditions. From a study of results of over 3,000 analyses of swimming pools in Detroit, the author concludes "that a bacterial standard could be based solely on a total bacterial count." This would eliminate much work in tracing down *B. Coli*. **Design and Operation of Small Filter Plants.** W. C. HIRN. 48-51. There are now 28 filter plants in Michigan, with two more under construction. About sixty plants are still needed to treat the surface supplies and the extremely hard ground water supplies in the state. Filter plants of capacities of 600,000 to 1,000,000 gallons per day will cost about \$30,000. Any Michigan municipality of 500 population should be able to finance the construction and operation of a filter plant for itself. Economy must be key note of design for small plant. Indicators, recorders, controllers, and mechanical equipment should be reduced to the minimum. The essential functions of the plant should be left accessible and observable. Dry and accessible pipe galleries are important. Filter media should be suited to the quality of the water and

operating conditions. The laboratory should be carefully planned. **Developments in Water Purification and Water Softening.** CHARLES P. HOOVER, 51-57. This paper gives a brief but accurate and interesting description of new processes and equipment for water treatment. The discussion covers chlorination, superchlorination, prechlorination to assist coagulation, double coagulation, the impregnation of slow sand filters with aluminum hydroxide, new equipment for handling chemicals and mixing them with the water and for the continuous removal of sludge, water softening by zeolite and lime, the softening of flood water, and recarbonation.—R. L. McNamee.

**Report on Pollution Survey of Cheat River Basin (West Virginia).** LEWIS V. CARPENTER and L. KERMIT HERNDON. State Water Commission, 46 pp. This report presents in detail the findings and conclusions reached after a methodical pollution survey of the basin of Cheat River. The object of the survey was: "(1) location and classification of waste waters into two classes, namely, (a) organic wastes, which are putrefactive and (b) inorganic wastes, non-putrefactive; (2) determination of the quantity and quality of the waste; (3) determination of the effect of the wastes on the river conditions; (4) determination of the effects of natural stream purification and the recovery of the stream from pollution; (5) study the condition of Lake Lynn." The equipment used on the survey was combined into a special field kit containing all necessary chemical equipment and reagents for making field determinations of pH, acidity, alkalinity, turbidity, color, and dissolved oxygen. Biochemical oxygen demand determinations were made in the Sanitary Engineering Laboratory at West Virginia University. A triangular and a rectangular weir, level, measuring rules and tapes were carried in the field. As the result of many measurements coal mine drainage was estimated to be about 1,000 gallons per day per acre of coal worked out. The quantity of drainage in deep mines does not fluctuate with the rainfall, so that as much acidity enters the streams during times of low flow as during high flow. The formation of acid mine water is explained as follows:

"Practically all of the coal seams in this district contain iron and sulphur in the form of pyrites or marcasites. Before the coal is mined, the air and water cannot get to these pyrites and the drainage is neutral. On exposure to air and water the following chemical reaction takes place:  $2\text{FeS}_2 + 7\text{O}_2 + 2\text{H}_2\text{O} = 2\text{FeSO}_4 + 2\text{H}_2\text{SO}_4$ , and is followed by:  $4\text{FeSO}_4 + 2\text{H}_2\text{SO}_4 + \text{O}_2 = 2\text{Fe}_2(\text{SO}_4)_3 + 2\text{H}_2\text{O}$ . As the water comes into further contact with the air, hydrous oxides are precipitated which give the familiar brownish-yellow color to rocks in streams that carry "sulphur" water. After the rocks are coated with this iron deposit, the acid in the stream has no further access to whatever neutralizing elements the rocks may contain, and the only further change in the acid condition of the stream waters is from the natural alkalinity of fresh water tributaries, the process of dilution."

No practical economical method of treating mine water has been found. Detailed data are given concerning the quantity and character of wastes produced by the plant of the Parsons Tanning Company at Parsons, West Virginia. The quantity of wastes from this plant are summarized as follows:

|                            |         |
|----------------------------|---------|
| Gallons water per day..... | 281,987 |
| Pounds of hide worked..... | 21,000  |

*Gallons of waste per day per 100 pounds hide*

|   |       |
|---|-------|
| Soak, wash, wheels, hide mills, mills, soak vats.....           | 458   |
| Lime vats.....  | 22    |
| Hot water.....  | 73    |
| Unhairing machines, flesh trimming, wheels, floor wash, etc.... | 333   |
| Float box, cold pools, etc.....                                 | 90    |
| Hairwashing.....  | 1     |
| Total beam house waste.....                                     | 977   |
| Vegetable tan liquor.....                                       | 91    |
| Leather wash, etc.....  | 8     |
| Bleach waste.....   | 20    |
| Total waste.....  | 1,096 |

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Total waste per 65 pounds hide, gallons..... 712

Descriptions of other less important industrial wastes and sewage reaching the streams of this basin are given. The paper is concluded with a statement of the effects of the various wastes upon the natural quality of the streams and with a number of suggestions and recommendations as to means of improving these conditions. A number of appendices present detailed data pertinent to the study, as well as established standard methods for stream pollution surveys in West Virginia, and adopted forms for securing information on industrial wastes and coal mine wastes and for recording the data of biochemical oxygen demand analyses.—*R. L. McNamee.*

**The Homo Method Applied to Nitriding of Steel.** Bulletin 950, 1930. Leeds and Northrup Company, Philadelphia, Pa. "Nitriding is a way of putting an intensely hard surface on a steel part. The process consists of exposing the steel for some hours to hot ammonia gas; the ammonia breaks down, because of the heat, into nitrogen and hydrogen, and the nitrogen reacts with the steel, and forms the nitride case. The nitrided surface is so hard that it resists abrasion to a greater extent than any other known steel surface. When polished it has an extremely low coefficient of friction. In addition to being intensely hard, the finished part very noticeably resists corrosion." This bulletin describes the automatically controlled Homo Nitriding Furnace.—*A. W. Blohm.*

**CO<sub>2</sub> Meters (Electrical).** Bulletin 781, 1929. Leeds and Northrup Company, Philadelphia, Pa. In addition to giving details of the L. & N. CO<sub>2</sub> meters a description of the economic significance of excess air; incomplete combustion; curves showing control of combustion, relation of CO<sub>2</sub> to excess air, effect of hydrogen in fuel, excess air and flue gas temperature, loss due to excess air, etc., and typical installation layouts are given.—*A. W. Blohm.*

**Power Cable Fault Bridge.** Bulletin 536, 1930. Leeds and Northrup Company, Philadelphia, Pa. The L. & N. Power Cable Fault Bridge is an instrument for locating a fault in a cable by the Murray Loop method. Full particulars are given in this publication, and some examples of its use in locating faults are included.—A. W. Blohm.

**Galvanometers.** Catalog 20, 1930. Leeds and Northrup Company Philadelphia, Pa. The galvanometers listed in this catalog are those which as experience has shown, will cover practically the entire range of applications for which galvanometers may be used. Among the instruments listed are three designed for extremely high sensitivity. A bibliography of the representative literature available on the moving coil galvanometer is included.—A. W. Blohm.

**Metered Combustion Control.** Bulletin 660, 1930. Leeds and Northrup Company, Philadelphia. "The object of combustion control in a boiler plant is to keep the rate of combustion constantly in accord with the demand for steam, to maintain uniform header pressure with efficient combustion and correct furnace pressure. With effective control, each furnace is supplied with the quantity of fuel that is required for the steam load on the boiler and with the quantity of air that will insure minimum net loss due to incomplete combustion and escape of heat in flue gases. A modern boiler plant equipment includes various devices intended to enable the operator to maintain conditions essential to efficient steam production. It is the purpose of the bulletin, to describe L. & N. Metered Combustion Control equipment by which such conditions are maintained automatically. With this equipment, metered quantities of fuel and air are supplied to each boiler in an accurate ratio and in immediate and proportionate response to steam load demand, while uniform steam pressure and correct furnace pressure are maintained."—A. W. Blohm.

**Klinck Test and Puddle Plug.** H. W. Clark Company, Mattoon, Illinois. This article is described by the manufacturer as follows: "The Test and Puddle Plug serves two purposes. It is inserted in the end of the pipe and tightened in place. This plugs the pipe and allows the water pressure to be applied for testing the joints. Dirt is then dumped into the trench a few feet behind the end of the pipe to form a dam across the trench. A short piece of two inch pipe or hose is coupled into the Test and Puddle Plug and water from the main is allowed to fill the trench behind the earthen dam and the soil is dumped into the trench. No tamping is necessary as the soil packs as it is dumped in trench. While the trench is being filled the Test and Puddle Plug may be removed to allow the laying of additional main. By this method the trench may be backfilled as the work progresses thus eliminating the danger caused from open ditches."—A. W. Blohm.

**Atlantic Coastal Plain. Surface Water Supply of United States, 1925: Pt. 1, North Atlantic Slope Drainage Basins.** NATHAN C. GROVER, chief hydraulic engineer, C. H. PIERCE, H. B. KINNISON, A. W. HARRINGTON, O. W. HARTWELL, and A. H. HORTON, district engineers. 1930. U. S. Geological Survey. Water-Supply paper 601.—Arthur P. Miller.

**Mississippi River. Surface Water Supply of United States, 1926: Pt. 7, Lower Mississippi River Basin.** NATHAN C. GROVER, chief hydraulic engineer, H. C. BECKMAN, ROBERT FOLLANSBEE, J. B. SPIEGEL, and C. E. ELLSWORTH, district engineers, 1930. U. S. Geological Survey. Water-supply paper 627.—*Arthur P. Miller.*

**St. Lawrence River. Surface Water Supply of United States, 1926. Pt. 4, St. Lawrence River Basin.** NATHAN C. GROVER, chief hydraulic engineer, S. B. SOULE, H. E. GROSBACH, A. H. HORTON, LASLEY LEE, A. W. HARRINGTON, and H. B. KINNISON, district engineers. 1930. U. S. Geological Survey. Water-supply paper 624.—*Arthur P. Miller.*


**San Joaquin River. Surface Water Supply of San Joaquin River Basin. Calif., 1895-1927.** H. D. MCGLASHAN. 1930. U. S. Geological Survey. Water-supply paper 636 D.—*Arthur P. Miller.*

**California. Surface Water Supply of Pacific Slope Basins in Southern California, 1894-1927.** H. D. MCGLASHAN. 1930. U. S. Geological Survey Water Supply Paper 636-E.—*Arthur P. Miller.*

**Hudson Bay. Surface Water Supply of United States, 1925: Pt. 5. Hudson Bay and Upper Mississippi River Basins.** NATHAN C. GROVER, W. A. LAMB, S. B. SOULE, J. B. SPIEGEL, H. E. GROSBACH, and H. C. BECKMAN. 1929. U. S. Geological Survey Water Supply Paper 605.—*Arthur P. Miller.*

**Ohio River. Surface Water Supply of United States, 1925: Pt. 3, Ohio River Basin.** NATHAN C. GROVER, A. W. HARRINGTON, A. H. HORTON, LASLEY LEE, H. E. GROSBACH, W. R. KING, and E. D. BURCHARD. 1929. U. S. Geological Survey Water Supply Paper 603.—*Arthur P. Miller.*





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